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METHODS FOR THE PROTECTION OF SECURITIES, CHECKS, IDENTITY PAPERS, AND SIMILAR DOCUMENTS

Die Sicherungstechnik der Wertpapiere [Methods for the Protection of Securities], 1935, Zurich, Pages 1-5 and 8-168

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METHODS FOR THE PROTECTION OF SECURITIES, CHECKS, IDENTITY PAPERS, AND SIMILAR DOCUMENTS

INTRODUCTION

The frequency of counterfeit bank notes, lottery tickets, stock certificates, bonds, treasury notes, railway and admission tickets, checks, letters of credit, receipts, contracts, ship's papers, and stamps is a matter of common knowledge confirmed by police statistics. The counterfeiters' motives are not always associated with personal gain; often they are of a political nature. Napoleon, for example, had counterfeit Austrian gulden and Russian ruble notes printed to pay for the acquisitions his army made in those countries. More recently there were the Czerwonky counterfeits and the Hungarian false French 1,000-franc notes. Once an idealistic Austrian scientist, too, turned counterfeiter -- to finance his successful researches in malaria.

The state, the banks, and private individuals annually suffer enormous losses as the result of counterfeit negotiable papers, bank notes, etc. While it is usually possible to detect and punish the criminal, the damages are only rarely made good. Furthermore, certain types of counterfeiting cause far greater damage, and injure a far wider group, than the monetary value of the false paper that is circulated. The market price of a stock or other security, for example, may fall catastrophically as soon as it is known that false certificates are in circulation, while public confidence in the issue is only slowly regained. For this reason many cases of counterfeiting are kept secret by interested parties -- banks, for instance, in the case of checks. Many other cases never come to light:

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a criminal arrested recently on another charge ironically informed the Paris police, to their amazement, that he had printed and sold thousands of tickets to the Colonial Exposition there in 1930. The American Secret Service in a single year dealt with 250,000 counterfeit dollar bills. Many other examples could be cited.

There can be no doubt that governments, municipalities, banks, steamship companies, and all those concerned with negotiable papers -- the general public, in fact -- have a direct interest in the prevention of all kinds of forgery and counterfeiting. To reach this goal is the task of security techniques for the protection of currency and negotiable papers.

All countries have stringent penal laws against forgers and counterfeiters, and the League of Nations is also concerned with them to some extent. Central offices for dealing with counterfeit money, like that of the German Reichsbank, have been set up. Banks are organized for action. When a counterfeit bill or forged check appears, the information is swiftly circulated. All these measures are useful, particularly in the detection of counterfeiters and forgers and constitute part of the security system. However, they do not suffice to render forgery or counterfeiting impossible. To do this is the task of security techniques for the protection of currency and negotiable papers.

To carry out this task, security techniques are based first of all on the principle of multiplying the difficulties that stand in the way of counterfeiting or forging a bill or document. At first glance we might be inclined to doubt the effectiveness of this principle, as everything produced by man can, a priori, be

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imitated or reproduced identically by others. Though the objection is valid in principle, there are a number of cases in which an individual is able to achieve a certain effect which he himself, to say nothing of others, is not able to repeat -- or could repeat only by a most improbable accident. (Koegel's principle of safety advice and other protective techniques, especially those used in printing and engraving.) In these cases actual technical imitation must be considered impossible. But the possibility of a counterfeit still exists. In Koegel's most valuable procedure there is still an element of uncertainty -- man. For control microphotographs etc equivalent must be retained by control officers, and thus the possibility of counterfeiting enters, in that the control document can be replaced by one that corresponds to a false document. Because these control officials are needed, the procedure is not adapted to the protection of many negotiable papers, such as banknotes. More important for these purposes are processes which systematically make imitation technically impossible -- at least with present-day techniques. Noteworthy among these are various secure printing processes. With these the possibility of counterfeiting the entire document can be made so extraordinarily difficult that it may be regarded as practically excluded. But although these processes already have rendered most important services, they cannot entirely eliminate fraud by falsified notes, checks, or documents. For, while they are of inestimable value when used by experts, they are quite useless in the hands of untrained or careless persons. These are, and always will be, the outer limits of the possibilities for protection and security. Even if an intrinsically perfect security technique should come into general use, bank notes and other negotiable documents would continue to be falsified, because there will always be

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forgers and counterfeiters who profit by the inexperience or carelessness of their fellows. But in the measure that protective techniques are perfected and applied, the criminal's risk will be increased and his chance of gain reduced.

Another triumph of the protective techniques lies in the fact that the alteration of the content of a written document, such as a check, today may be regarded with practically complete certainty as impossible.

Many of these achievements of the protective techniques only date back to the last few years or decades. Unfortunately, however, it must be noted that these improved protective methods are only gradually being introduced, and that even now they encounter a great deal of mistrust. To some extent this is because so-called safety papers frequently appear on the market which are supposed to be forgery-proof, while an expert would consider it child's play to counterfeit them or especially to alter their content. Even today the postal money order forms of most countries, the blank checks of most banks, etc, are not only easily imitated but their written content is even more readily susceptible to falsification. Although these facts may amaze us, they become understandable when we stop to think that a lot of inadequately "secured" papers appear on the market and that the authorities who decide on the implementation of security measures lack the necessary technical knowledge -- which is hardly surprising. Likewise, the manufacturers of so-called "safe" papers often are quite unclear about the properties which their product should possess. In many places, protective techniques are still at a low level of development and drastic measures are required to seize the victory. This is what the Danish newspaper

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publisher K. C. Aller accomplished in an era when today's technical means of protection were still far in the future. In 1909 he forced the Danish National Bank to recall an issue of 10-kroner notes by counterfeiting them and then confessing his crime and submitting the serial numbers involved. The notes were later reissued in a more secure form. As Aller acted on purely idealistic grounds, without seeking to enrich himself, he was not prosecuted. The Danish National Bank in fact was obliged to thank the critical publisher, as he undoubtedly saved it from having to redeem a great many false notes.

When a counterfeiter succeeds completely there is no way of telling the difference between the genuine and false notes. Often it is only the application of technical protective procedures that reveals the counterfeit, if it is discovered at all. Certainly the protective procedures adopted to date, even if they offer all too little security in themselves, have prevented a large number of cases of forgery and counterfeiting, in a purely psychological sense -- in that they inhibited or deterred the criminals.

Progress in the protective techniques not only serves to discourage forgery and counterfeiting, and the consequent losses; it can be fruitful in many other ways. There can be no doubt that a completely protected, safe check would make possible not only a basic simplification of the way in which banks handle checks but also a much more widespread use of this convenient form of payment than heretofore -- at least in Europe in contrast to the United States. (In the United States, of course, children are taught about the use of checks in school and learn how to handle a check book.) Thus the check would achieve its real importance as a circulating

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medium payable "at sight." At present it has largely lost this meaning in practice, simply because of the doubts evoked by forgeries -- the banks make payment on certain checks only after the fulfillment of various formalities. In this connection a decision of the Court at Paris of 30 April 1931 may be noted. A bank had delayed payment on a bearer check because advice of it had not been received. The bearer of the check brought suit and won. The court held that it was unlawful for the bank to make immediate payment dependent upon the fulfillment of formalities not set forth in the statutes, and thus to delay payment.

The enormous public relations advantage over its competitors accruing to a bank that uses really well protected blank checks is obvious -- aside from the other advantages.

The following lines concern themselves with the most salient elements of modern protective techniques for safeguarding bank notes, checks, and other negotiable papers. These elements can be combined to achieve a more or less complete degree of security answering every protective need. It has been impossible to discuss in detail every combination of elements without exceeding the planned length of the work, and many combinations are only indicated or touched upon. The more or less complete discussion of counterfeiting and forgery methods, and of methods of falsification not yet adopted is not included to encourage crime but to call the attention of the producers and consumers of safety paper stock to the requirements such paper must meet, and particularly to alert the consumers -- banks, for example -- to the dangers that threaten them.

As the methods of counterfeiters and forgers are constantly being improved and refined, it is necessary for protective techniques

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to be in continuous development. Numerous avenues of development stand open, on the basis of present-day science and technology. All of them could not be treated in this book. However, a thoughtful application of the methods given herein should yield solutions to most protection problems which will be adequate for the great majority of practical purposes for a long time to come, and which are beyond the present technical level of the forger.

Chapter I. Counterfeiting and Forgery

Technical or protective methods for combating counterfeiting and forgery can be evaluated and analyzed only after one has been acquainted with the operations of counterfeiters and forgers in some detail.

Depending on the kind of fraud contemplated and the nature of the object to be falsified, the criminal, is confronted with the following problems:

1. The imitation of a bank note, check, or similar paper, in all its details, including the paper stock, watermark, engraving etc. In this case a genuine document is replaced by a spurious one -- which will be referred to hereinafter as counterfeiting. In ordinary language this imitation of a negotiable paper is often called forgery. Total falsification is the total imitation of a paper. Counterfeiting is especially common with negotiable papers like bank notes, stocks, bonds, etc. (Between 1921 and 1929 12,000,000 French francs' worth of counterfeit bank notes were in circulation in France alone. Losses from counterfeit stock certificates in the last few years amounted to some 100,000,000 francs.)

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2. Alteration of the content of a negotiable paper in certain details, such as the elimination of certain written characters and their substitution by others, in an otherwise genuine document. This is essentially an alteration of the content, which we can refer to as content forgery. However, for the sake of brevity, this will usually be referred to simply as forgery, as it is called in ordinary language. It is especially commonly practiced on unsafe paper stock, in which case it is done with the greatest of ease.

3. The imitation of the handwriting or other technical authentication of the intent of an individual -- that is, the falsification of identity in an otherwise genuine or spurious document without counterfeiting or content forgery. This is particularly common with checks and the autographs of famous personalities.

Counterfeiting is usually a matter of imitating a paper stock, a given watermark, a printing type, an ornament, or a character. None of these presents any great difficulty for the specialist. An experienced paper maker can easily manufacture paper with a well-known watermark, while a printer or engraver can imitate a known blank form exactly enough. Draftsmen, artists, and many unskilled persons succeed notoriously well in imitating handwriting, signatures, etc, more or less exactly. All these professionals need only use their professional tools -- machines, apparatus -- to do their jobs. It would carry us too far to describe these techniques in detail here. Presumably there are detailed technical treatises in most languages; acquaintance with them is assumed in the following, except for special tricks used mainly by forgers. The latter are best dealt with in the discussion of individual protection processes, and are omitted here in order to avoid repetition. There, too, belong

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the general remarks on the standard operating procedures of the professional counterfeiter and forger.

Content forgery involves changing the content or meaning of a document. Handwriting, type, etc are removed or obliterated, and thus rendered invalid, to be replaced -- when necessary -- by handwriting or printing with another meaning. In other cases alteration of the significance is accomplished by rewriting alone. Content forgery can be carried out with or without removal of those portions of the paper which carry the characters to be removed or obliterated.

I. By removing those parts of the paper which bear the writing. This can be done as follows.

1. By rubbing off the characters when they lie on the surface or in the topmost layers of the paper, as is usually the case. For this we use the term mechanical erasure -- erasure for short -- which is commonly known and usually done with a pen knife, rubber eraser, abrasive paper, etc. The abraded area must of course be written over anew.

2. By splitting off the topmost layers of the paper which contain the characters to be treated -- for example by affixing a powerful adhesive paper, like the paper tape used in sealing packages, and then pulling it off. The top layers of the document, those holding the matter to be removed, are thus split off -- if not the first time, the process is repeated (see Figure 1).

3. By excision of portions of the documents which contain the matter to be removed, and insertion of new paper with new written content in the appropriate places.

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II. Without removing those parts of the paper that bear the writing. This can be done as follows.

1. By addition of superscription, such as transformation of a 1 into a 4, a 3 or 5 into an 8, etc (see Figure 2).

2. By covering characters to be rendered invisible. This can be done with colors either in dry form, like powder or chalk, or by impressing or stamping with transfer paper, for example, as well as with watery, oily, or other opaque paints. Thus, for instance, black printing can be completely covered with white lead oil paint. New characters can then be applied over the more or less concealed originals. In this way ticket No E 24922 of the French State Lottery of December 1, 1933 was forged and won the forger the sum of 1,000,000 French francs.

3. By bleaching with light, rendering inks invisible by applying the destructive action of light to the dyes they contain.

4. By chemical removal of characters (chemical erasure). This method is very frequently used, especially on documents written in ink -- particularly checks -- because it can often be accomplished without leaving any damage visible to the eye. In order properly to evaluate protective measures against this kind of forgery, the forger's chemical tools are discussed in some detail here. These are primarily ink bleaches or chemical eradicators.

Ink bleaches are chemical substances with which it is possible to destroy writing in ink. The principal ones are substances used in the textile industry as bleaches or corrosives -- etching chemicals; in general, they are oxidizing or reducing agents. They oxidize or reduce ink dyes to colorless compounds. But, depending on the ink,

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acids or other chemicals, such as alkalis, or solvents like alcohol, can be used to remove handwriting in such a way that the ink dye is either chemically transformed into a colorless substance or is mechanically dissolved out.

In the great majority of cases forgers use oxidizing agents that are sold on the market as ink eradicators under the generic name Tintentod [Ink Death]. Most important among the oxidizing agents are the hypochlorites -- soluble salts of hypochloritic acids, principally calcium hypochlorite or chloride of lime, sodium hypochlorite (also called Eau de Labarraque) and potassium hypochlorite (Eau de Javelle [Javel water]). These chemicals are mass produced, are used in paper and textile mills, laundries, etc, and are easily obtainable at any grocery or drugstore. The forger has no difficulty in getting hold of them. By far the great majority of dyestuffs on the market can be completely bleached out with them, especially in combination with hydrochloric acid. The writing to be eradicated is first moistened with the hypochlorite solution or paste, the excess chemical is absorbed with blotting paper, and the writing is then covered with hydrochloric acid, whereupon the ink disappears more or less rapidly, depending upon its composition. By using the hydrochloric acid before the hypochlorite the process can also be made to work in reverse order. The latter procedure has advantages over the former in that the paper stock is less affected. Hypochlorites have a rather strong alkaline reaction which softens or stains the paper (especially paper with wood pulp content) faster than does an acid reaction. The effect of the hypochlorites is based upon the principle of the oxidizing power of hypochlorite acids, which is liberated by the action of the carbonic acid in the air and much more rapidly by hydrochloric acid.

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The latter with hypochlorite acid becomes chlorine, which with water forms in part a new hypochlorite acid. Chlorine is a bleach in itself, which explains the expecially good, rapid effect produced by the application of hypochlorites and hydrochloric acid. The simultaneous application of the hydrochloric acid and hypochlorite is still more aggressive, in some cases attacking the underprinting of a check which resists the application of hypochlorite (chloride of lime) and hydrochloric acid applied successively.

Chlorates, whose action is essentially similar to that of the hypochlorites, are also good ink removers. A concentrated solution of sodium chlorate is applied to the ink, followed by dilute hydrochloric acid, whereupon most inks bleach out.

Next to the hypochlorites, potassium permanganate plays the leading role in the bleaching of ink. Like them, and because of its stability, it is found in many of the commercially available chemical ink eradicators. It has a neutral reaction and a strongly violet color, and like the hypochlorites when used with acids, particularly hydrochloric acid (in which case chlorine again results) it has a very strong effect. As a result of oxidation the violet color is changed to the brown of the manganese dioxide which is formed, but this is easily removable with a solution of either sodium bisulfite or sodium sulfite, or with acids.

Still other oxidizing agents can be used, like chromic acid or chromates, or bichromates in combination with acids. However, green colored chrome salts appear as byproducts of the oxidation, and they are not so easily removed from the paper. The effects of other oxidizing agents, such as persulfates or perborates, is based on the oxidizing properties of hydrogen peroxide, which is less pronounced than that of the agents previously mentioned.

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Organic oxidizing agents must also be noted. Aktivin (sodium paratoluolsulfochloramide) for example contains 23% of free chlorine, which is liberated very slowly, however. Benzoyl peroxide should also be mentioned.

The use of oxidizing agents in organic solvents must also be considered in certain cases, for with these the forger can largely avoid damage to the paper stock. Safety papers, including those with goffering, embossing, perforations, etc, can be treated in this manner with the utmost regard for the original impression and texture of the paper.

Writings in ink can also be erased dry with gases like ozone or chlorine. This method also preserves the original texture of the paper.

The following reducing agents are used for ink eradication: sulfurous acid and its salts, hydrosulfites and their more stable formaldehyde compounds, stannous chloride and titanous chloride of which the latter is by far the most effective. Sulfurous acid, easily available, combines with certain dyestuffs sometimes used in ink (fuchsine, malachite green, etc) to produce a colorless compound which is easily washed from the paper. Its soluble salts, such as sodium bisulfite, which develop sulfurous acid when used in combination with acids produce similar results. Sulfurous acid has little effect upon the most commonly used inks, but it bleaches ferrous sulfate, the basis of iron gallate inks.

Hydrosulfites, like sodium sulfite and its formaldehyde compounds (rongalites), are much stronger than sulfurous acid, especially in combination. They reduce ink dyes particularly if the

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latter are composed -- as they commonly are -- of artificial organic dyes. However, the hypochlorites are more effective. Hydrosulfites have an alkaline reaction.

Among reducing agents titanous chloride is most effective. Edmund Knecht (E. Knecht and E. Hilbert New Reduction Methods in Volumetric Analysis) of course proposed its use in the analysis of dyestuffs. So far forgers have used it little or not at all, perhaps because it is not found in commercial ink eradicators, is unstable in the presence of air, and is less easily available in shops than other ink bleaches. From the standpoint of protective technique it deserves special attention, however, because in acid solution it can completely bleach a long list of ink dyes, namely all azo dyes, thiazines, safranines, in addition to triphenylmethane dyestuffs, indigo, and many others. Titanium chlorate is violet in color but as a result of oxygen absorption or reduction turns into colorless titanic acid.

A long list of other acids -- inorganic and organic -- can be used as ink removers: sulfuric acid, hydrochloric acid, nitric acid, oxalic acid, tartaric acid, citric acid, acetic acid, and others, all of which are readily obtainable. The strongest of these, like hydrochloric acid or oxalic acid, have a destructive effect on ink dyes -- particularly on iron gallate -- or form colored solutions with them that can easily be washed out of the paper. The weaker acids have only a dissolving effect, like that of the organic solvents (like alcohol), which dissolve coal tar dyes but only attack iron gallate or logwood inks insofar as they contain organic anilin dyestuffs that are soluble in alcohol. Alcohol and the other organic solvents (glycerin, glycin, Azetin, etc) act slowly and are only partially effective.

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These are the most important chemicals capable of removing ink. A thorough knowledge of their application and their effects upon inks is necessary in order to take the necessary counter-measures. The basis of one of the most important protective measures is the production of papers, printing inks and writing inks that will indicate the application of chemical reagents as clearly as possible, so that attempts at forgery will be revealed and the potential victims warned.

While removal or bleaching of the usual writing inks is surprisingly easy and succeeds admirably. The elimination of printing inks and India ink, black typewriter printing, and pencil script by chemical means is more difficult. The great majority of printing inks are in media insoluble in water, such as boiled linseed oil, resin varnish (resin and mineral oil), etc, which dry with a water-repellent film and sometimes lose their solubility in solvents almost entirely. Such inks offer more or less strong resistance to the usual chemical reagents used on ink, and if they contain lampblack -- as do most black printing inks and temperas (finely divided lampblack in shellac, etc), every oxidizing and reducing agent fails. But if the binding medium is destroyed or dissolved -- alkalis, soaps, spirits of soap, etc are notably successful -- such inks can likewise be removed. There are also commercial products (Tuschex, Tuto, for example) designed to remove India ink from technical drawings. According to US patent No 1,488,881, (F. E. Jackson, Grosse Pointe, Michigan), these printing inks can be removed with a mixture made of:

1 part by volume turpentine (as solvent)

1 part by volume glycerin (to retard the evaporation of the alcohol and ammonia)

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1 part by volume ammonia (effective solvent for the binding medium)

2 parts by volume alcohol (as solvent and detergent, and to minimize the effect of the ammonia upon the paper stock)

2 parts by volume soap (to prevent too rapid evaporation and drying out) plus starch paste to give the mixture a thick consistency, so that it will not run and can be confined to the portions of the document that are to be erased. The starch also absorbs the pigment released by the solvents from the binding medium. The paste is applied to the writing or drawing to be removed. After a sufficient working time, the affected characters can be rubbed off with a cloth or bits of paper, or lifted off with the point of a knife. Many other such eradicators for printing inks can be devised.

As far as the falsification of identity is concerned, this, too, is usually accomplished with ease when the forger has only to imitate the handwriting or a signature. Signatures are wrongly and still too widely regarded as the personal, sign of a particular individual which cannot be imitated perfectly. In contrast, E. Locard, in his Manuel de technique policiere, page 195, writes that the determination of the genuineness of an individual signature is extraordinarily difficult. "It is certain that a practiced, clever forger can imitate a signature perfectly enough to render a diagnosis virtually impossible, while in a longer manuscript the graphometric method leads to the goal with complete certainty. On the other hand, a semiilliterate may have such wide variations in his signature that the range of variations may include the inaccuracies of the forger."

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For the various methods of imitating signatures see E. Locard's Traite de Criminalistique.

It is desirable or necessary in many cases to apply the various protective procedures in combination with each other, as it is of course advantageous from the standpoint of protective technique to preclude as many possibilities of forgery as possible. What is to be guarded against in a given case is determined by the nature of the note or document to be protected. For example, a bank note need not be protected against alteration of a signature written in ink, as writing ink is not used on a bank note. In the case of bank notes, the best assurances of authenticity are those which are easily verified.

Protection principles can by applied either to the paper stock, the press work, the printing ink, etc. For the sake of clarity the discussion of these specific protective methods is broken down into general, paper, press, and writing ink techniques.

A sharp differentiation is not always possible, as a large number of processes are based upon various combinations of protective measures. In order to avoid repetition, the general measures are discussed with the technical methods for the protection of paper stock.

Just as falsification of notes and documents can be divided into counterfeiting, content forgery, and forgery of identity, so the protective measures can be divided into the following categories.

Authenticity safeguards, which aim at protection against imitation.

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Safeguards against forgery of contents or forgery-proofing, which seeks to render falsifications of the contents of a document impossible or easily recognizable.

Safeguards against falsification of identity, preventing imitation of a mark which guarantees the expression of a personal will.

Chapter II. Protection Against Counterfeiting -- General Safeguards and Techniques in Paper Making

The most important principle in ensuring authenticity consists in the production of paper, presswork, printing ink, writing ink, etc, in unusual ways which are as difficult as possible to imitate. Whether a given paper was manufactured in one specific way, and in no other, must be ascertainable more or less easily, either at an inspection office or by all persons concerned with the document, who have access to certain tools. The value of a given protective process is measured by the difficulty of imitating the safeguard it contains, and by the ease with which its identifying feature is unmistakably recognizable.

A further principle used in ensuring authenticity is based not on difficulty of imitation or production, but on difficulty of discovery. There are, for example, secret marks or symbols agreed upon by the interested parties -- but the possibilities of applying this principle are limited. Still better, in certain cases, is authentication by matching pieces. This principle covers a device frequently used for special purposes, whereby a portion of a document with some complicated pattern is cut off and kept. Genuineness is determined subsequently by putting the 2 pieces together to see whether they and the patterns match.

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In given cases all these principles may be combined, which immeasurably increases the security.

Assurance of the authenticity of paper stock is based essentially upon some identifying feature which ordinary paper does not have. This feature should be integral with the paper itself, insofar as possible, in order to make imitation difficult. It may be associated with the use of a costly machine -- the paper-making machine, for example. Several processes are based upon this principle, but they cannot be deemed particularly valuable, for with another paper-making machine, or certain other devices, indentical or similar effects are obtainable. Furthermore, miniature experimental paper-making machines are available commercially, and the possibility that counterfeiters can get hold of them must be reckoned with. Yet there are distinguishing features which must be considered impossible to counterfeit in detail, even with a paper-making machine. Unfortunately these methods are at present not applicable to documents such as bank notes. For them, we are limited to the choice of a paper as difficult as possible to imitate, but whose inimitability is not entirely satisfactory.

The known varieties of identifying features in safety papers may be conveniently divided into the following categories, which will also provide a good survey from the standpoint of protective techniques.

A. The safety paper as a whole is provided, in the most complicated, most difficult manner possible, with properties differing from those of ordinary paper. These special properties can be produced by means of a specific material alone or by means of the tools of the paper-maker's trade alone. The distinguishing

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feature may be identified either directly, i.e., by the human senses alone, or indirectly, by means of physical or chemical aids. The identifying marks may be further divided as follows.

A. I. Directly perceptible characteristics, i.e., those which can be perceived by the human senses alone -- sight, hearing, touch, taste, smell.

Direct visual recognition of authenticity is by far the most important, but it is relatively unimportant for simple, uniform papers. The eye can distinguish color, uniformity by reflected or transmitted light, and surface finish (glass, smoothness, roughness), the length of the fibers and possibly their material nature -- plus special additives like glitter, gold flakes, etc.

Hearing gives us the sound of the paper -- the property which often has aroused the first suspicion of forgery. With the aid of the sense of touch the surface roughness, hardness, and approximate thickness and weight of a paper can be felt. The odor of a document offers no basis for determining its authenticity unless the odor has been developed subsequently by special chemical treatment. Paper might be scented with perfume, but scents are so easily transferred from one sheet to another upon mere contact that imitation would be no problem for the forger. Virtually the same can be said about taste, and for sanitary reasons no one -- generally speaking -- can be expected to test negotiable papers or bank notes with his tongue. However, certain foul-tasting substances might be usable in rare cases.

A. II. Indirectly perceptible features. These are marks which can be made visible or otherwise perceptible by means of

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physical or chemical procedures. Physical properties may be recognizable by mechanical, optical, electrical, or magnetic means. These methods will be discussed further under B below. Because of their general applicability and to avoid repetition, we shall now turn to a discussion of chemically recognizable marks.

Chemical assurance of authenticity is based upon the concept of applying to a paper -- all or only parts of it, such as the printing or the writing -- a substance -- visible or invisible to the eye -- which will produce a color reaction -- or some other easily recognizable reaction -- when treated with a given reagent. The signal reaction is the feature which establishes the authenticity of the paper, printing, or writing.

In principle, all the color reactions known to chemistry may be used to produce such a signal reaction, provided that the substances are compatible with the paper and inks, etc, are sufficiently stable to air and atmospheric influences, and do not evaporate or sublimate. The requirements for the reagent to be applied in testing -- hereinafter called the test reagent -- are not necessarily so exacting, but on practical grounds the same requirements would be desirable.

A great number of reactions familiar in analytical, inorganic, and organic chemistry, as well as in the chemistry of dyestuffs, may be adopted as signal reactions in the chemical determination of authenticity. But substances for producing color reactions which are easily available to all -- so that forgers can identify and imitate the color reactions by means of a series of experiments with genuine documents -- in themselves offer a very slight, or

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illusory, degree of safety. Therefore further processes, more difficult to imitate, have been sought.

Thus, in Austrian patent No 92,282 (J. Ehrlich, Vienna), the variations in the capillarity of paper fibers in relation to various solutions of different concentrations were used to make the imitation of chemical signal reactions more difficult.

If, for example, a 1% alcoholic solution of dimethylglyoxim is mixed with a 4.5% solution of sodium salicylate in 80% alcohol, in a specific proportion -- 1:4 for example -- and this liquid is coated on a well-sized paper; the prepared paper, touched with a reagent composed of a saturated solution of nickel nitrate and a 10% solution of ammonium ferric alum in an exact proportion -- 6:2.5, for example -- will develop a spot of color which is violet in the center and has a concentric red ring around the outside. By virtue of the varying absorptivity of the paper fibers to the solutions of differing concentrations, the liquid mixture separates and a 2-color reaction, in fact one with a distinct, sharp line of demarcation, is produced. It is achieved, however, only if the coating mixture and the test reagent are exactly adjusted to each other and to one and the same kind of paper. A slight alteration in the system of compatible reagents, by variation of the concentrations or of the proportions of the mixtures, would suffice to ensure failure of the 2-color signal reaction, producing all possible color mixtures from blue-violet to red, gray, or gray-yellow -- but not the pure and sharply separated colors. With one particular mixture another 2-color reaction would result, but it would be red inside and violet outside. This, however, is still more difficult, and is not possible with every kind of paper.

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Such a substance for coating or impregnating paper, because it produces a 2-color reaction, differs first and foremost from the hitherto customary sympathetic inks which give only monocoloric reactions; secondly, it provides an essential improvement over the hitherto customary chemical methods for the recognition of documents, etc, for the following reasons.

(a) The proportions of the mixtures may be varied at will, much as the combination of a lock is rest.

(b) And just as a skilled locksmith is unable to open a combination lock with all his tools and expert knowledge, this procedure presents the expert with virtually insuperable difficulties if he tries to discover the formula for the coating through chemical analysis or empirical investigation. This offers broad protection against falsification.

(c) The signal reaction appears instantly, so that identification is rapid and does not interfere with mass handling.

(d) Only offices authorized to review documents, negotiable instruments, etc, can possess the facilities for making the test.

Other substances, too, may be used similarly in the authentication of documents. For coating or impregnating the paper one may use for instance: dimethylglyoxim, sodium salicylate, potassium ferro-cyanide, potassium succinate, potassium citrate, etc. And as test reagents -- nickel salts (sulfates of nickel and ammonium), ammonium ferric alum; copper sulfate, and others.

Ehrlich gives further interesting examples of the applications of these chemical tests one for passports, which of course are rather frequently counterfeited, and one for signatures in ink.

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The blank passport form is impregnated with an extremely dilute solution -- almost water-clear -- of potassium ferrocyanide. When a visa is to be inserted, the authorized official, after he has affixed his signature, applies a 2% alcohol solution of dimethylglyoxim to a predetermined area with a brush. The alcohol evaporates immediately; there is no time-wasting procedure to impede large-scale operations. Since only the authorized official is in possession of the second part of the impregnation formula, indisputably genuine forms cannot be issued by unauthorized persons, nor can signatures or rubber stamp impressions be forged. At border check points, the control officers apply a carefully compounded solution of ammonium ferric alum and nickel nitrates to the impregnated paper, perhaps by means of a rubber stamp, whereupon green letters, symbols, etc with red borders are instantly made visible.

Such mixtures, applied as impregnation materials, are adapted also when falsifications of signatures are to be feared. It is only necessary for checking purposes to affix a second signature, using the liquid mixture. Such a signature is difficult to forge because the alcoholic medium evaporates as soon as it leaves the pen, depriving the forger of the possibility of producing a good imitation, since it cannot be gone over even once. Such written characters also show up with red borders upon application of the correct test reagent.

Chemical authenticity testing need not always rely upon color reactions in the ordinary sense of the word. Substances that act as catalysts to color reactions also may be employed. Ehrlich gives an example in the previously cited Austrian patent No 92,282.

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Postage stamps may be impregnated with substances which do not themselves produce color reactions, but only initiate or intensify such reactions between 2 other materials. In such a case the color reaction proper takes place between the dyestuff in the stamp-pad ink with which the stamp is cancelled and an additive to the stamp-pad ink. The additive consists of substances capable of condensing when combined with the aniline dye of the stamp-pad ink -- but only in the presence of certain other substances, whether catalysts or desiccating agents, like magnesium chloride. The postage stamp is impregnated with the latter. When the stamp is canceled, the condensation of the cancellation ink with its additive occurs on the stamp, where it immediately shows up in a quite different color -- metallic green sheen, for example -- than on the paper on which the stamp is pasted. Any of the universally obtainable stamp-pad inks which contain an aniline dye, such as methyl violet, may be used. Thus, identification of the authentic stamp is accomplished automatically by the canceling machine. The substance in the ink of the stamp is not a sympathetic ink, and the whole procedure is quite different from that first described. Furol, for example, and other aldehydes which easily enter into condensation reactions, are adapted for use as additives in the stamp-pad ink.

Chemical authenticity tests may also be complicated for instance by impregnating paper with a substance which with the test reagent does not produce a color reaction visible to the eye but is visible in ultraviolet, infrared or other invisible rays. This would constitute a combined chemical-invisible ray test. It would have the advantage, for example with passports, that a forger would be quite unaware of the presence of a chemical authenticity safeguard, and of the need for special precautions.

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This last advantage also applies in a certain sense to the process in German patent No 397,363 (H. Graefe, of Leipzig-Sellerhausen and Doctor Martin Wadewitz, of Leipzig). In it, dyestuffs such as sulfuriferous organic dyes, "vat" dyes etc, which have been treated with alkalis or reducing agents, or both, are applied to the paper stock, producing a characteristic enveloping color which disappears upon exposure to air, regenerating the original dyestuff. Paper thus dyed or patterned -- with anthraflavone G, for example -- is tested by dampening with an alkaline hydrosulfite solution. The dampened area exhibits a red-brown coloration, which disappears after removal of the test reagent by blotting.

All "vat" dyes have the property of turning white, or "vatting," -- adverting to their leuco-bases -- with the help of reducing agents in an alkaline medium. Often reduction will take place only in the presence of heat, however.

The most important vat dye is blue indigo. Others available commercially in all colors are the Algol dyes, the ciba, helindone, hydrone, indanthren, and thioindigo dyes. Often these dyestuffs will react against hypochlorite and other bleaching agents, and papers dyed with them thus serve also as forgery indicators (q.v.).

The leuco-base solutions of the sulfuriferous organic dyes, in contrast to those of the "vat" dyes, usually are little different in color from that of their final stage after "vatting," so that they are less suitable for use as indicators in the manner described. With acids -- even weak organic acids -- many sulfuriferous dyes react by the displacement and splitting off of free sulfur or hydrogen sulfide. They are stable to greatly diluted oxidizing agents, such as chromic acid, hydrogen peroxide, sodium perborate, etc; many are

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even rather stable to chlorine. Chlorate etching, however, destroys sulfuriferous dyestuffs, though it does not leave them as colorless products. Alkaline reducing agents "vat;" acids likewise destroy the colors, while steeping in soda lye has various effects.

Spotting the paper with solutions which must be wiped or dried off is impractical, so test reagents are often applied in pencil or crayon form. Thus, the Bank of France will not make final payment on a check unless it develops a certain striking color where it has been marked with a special pencil; the paper produces the color in reaction with the substance in the pencil. According to French patent No 757,540, (A. Deplanche), which gives information on mechanical production, the ink coating the check must contain a considerable sediment of the material which changes color when the pencil is applied. But this surplus should not be achieved by use of a thick layer of ink, or it might be possible for a forger to alter the writing or printing on the check and still leave enough of the chemical coating to produce the color change in response to the test pencil. The patent cited above contemplates application of the coating by means of a device based on the familiar roller type of applicator, which applies a coating so thin that any mechanical or chemical erasing will destroy it. The sensitive substance comes in a sticky, moist, watery medium and is not further described. In principle, all protective color-sensitive substances may be used, provided they can be produced in stick form -- which should not present any special difficulties for stable substances not subject to sublimation. Such crayons are usually quickly used up. However, metal pencils can also be used and sensitive substances used such as white lead, zinc white, lead carbonate, etc. These substances,

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when marked with metal pencils (especially gold, silver, or brass) (on the principle of graph paper metallic papers ["Diagrammpapiere"]) ... produce a black color, and it is interesting to note that L. Lebateux of Paris, in the Austrian patent Nos 10,301 and 12,999, as early as 1902 suggested the use of such combinations for security purposes. See also German patent No 416,430, (K. Rezsny of Budapest), concerning the production of a paper capable of being marked with a metallic pencil.

It is to be noted further that a paper containing soluble copper salts can be written upon with iron wire, as it liberates copper.

But all these materials and color reactions are generally known. Some of them are very frequently used in inorganic analysis. The materials are easily obtainable in any pharmacy. Thus it is doubtful that their use would result in effective security.

For assurance of genuineness only such substances should be used which are not available on the market and would have to be synthesized by a forger. Furthermore, they will be better suited for chemical authenticity tests if the general publications on analytical and color chemistry, etc, provide as little information as possible on the color reaction and the reagents involved. Ideal would be substances not yet described, which were discovered or developed by researchers for the specific purpose, and utilized with careful regard for secrecy as to their structure and manufacture. In these circumstances the forger would find imitation far more difficult than with most other means of protection, such as watermarks, etc, as he would first have to isolate the substances in sufficient quantity and then probably undertake a costly and time-consuming

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analysis to discover the ingredients and method of putting them together. In difficult cases such operations can only be carried out by specialized chemists, and even they do not always succeed -- or they may do so only after a long series of time-consuming experiments. Furthermore, the composition of a substance can be chosen in such a way that analysis is made particularly difficult. This is especially practicable in organic chemistry where completely satisfactory analytical procedures are not yet at hand. But if the identity of the substances is finally determined analytically, discovering methods of synthesizing them an equally vast knowledge of chemistry and an equally large number of experiments may be required. In the great majority of cases the forger lacks all this knowledge, as well as the necessary tools and apparatus. After fruitless attempts to identify the signal reaction he will give up, or else be easily apprehended. Only a large, well-organized ring of forgers, with ample funds, could attempt a job that promises success only after lengthy, difficult labor. To counter this last possibility, the ideal protection chemicals for one and the same document would have to be replaced by others after a certain length of time.

It is obvious, furthermore, that the ideal chemical protection substances should not be patented, and that all imaginable measures should be taken to make sure that these substances, or paper treated with it, or the test reagents, not be stolen or fall into the hands of unauthorized persons. A forger might extract the protective chemicals and transfer them to other, counterfeit, paper; or mix the genuine paper with other paper pulp, to manufacture a spurious paper which would produce the genuine signal reaction, perhaps even if in a weaker form. To counter this latter possibility, indicators would

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have to be used which would give the spurious paper a different color from the genuine paper -- the indicators in turn being protected against bleaching by other indicators. All these indicators, furthermore, ought to be protected against decomposition as a result of chemical or physical processes -- against solubility in various solvents for example.

On this basis, chemical assurance of the authenticity of documents is one of the most complete safeguards imaginable. An experienced chemist would ~~scarcely doubt~~ its practical applicability.

B. Safety paper is provided with a pattern composed of properties differing from those of ordinary paper, produced by methods which are as complicated and difficult to imitate as possible. This patterning may be accomplished with or without the addition of material, and may be recognizable directly or indirectly.

B. I. Directly recognizable identifying patterns may be produced as follows.

B. I. a. Without adding any substance extraneous to the composition of the paper. This can be done in the following ways.

1. By mere variations in the thickness of the layers of paper, or unequal distribution of the paper pulp.

Genuine watermarks are the result of that property of paper by which it appears to have varying degrees of whiteness, particularly by transmitted light, according to its thickness. A genuine watermark of course, is produced by weaving patterns into the mould (in hand made papers) or in the dandy-roll (in machine made papers), thus impressing these patterns into the web of wet paper. Thick or

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thin areas in the paper are formed according the pattern. Other phases of production are also important in the formation of the watermark, but the literature on the manufacturing process is plentiful. See such works as Schubert's Die Papierfabrikation [Paper Manufacture]. Watermarks with a 3-dimensional plastic effect, and "double" watermarks may be produced by machine as well as by hand, for instance according to German patents Nos 406,942 and 409,586 (J. W. Erken Machinery Works at Niederau). In this process an upper mould is used as well as a lower one. If desirable, it may be used with the most viscous of materials. Papers thus produced also have uniform tearing, stretching, and crumpling characteristics -- both longitudinally and transversely. "Plastic" or 3-dimensional watermarks are more valuable for purposes of protecting documents than the usual flat ones, which are very easy to imitate -- for instance by splitting off part of the paper. But, at least on the thicker papers, 3-dimensional watermarks can also be imitated.

According to US patent No 1,901,049, (F. von Heinrich, National Bank of Hungary), the photoengraving process is adequately adapted to produce watermarks in halftone (see also British patent No 373,905 and Austrian patent No 125,578). For the production of special forms of watermarks see US patent Nos 1882962, 1883184, 1883185, 1883187.

Genuine watermarks are among the oldest, most common means of assuring the authenticity of documents. In Germany the watermarks for official papers (for government officials) must be registered at one of the government materials testing offices, thus facilitating identification of origin and quality.

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According to German patent No 573587 and US patent No 1,825,796, (S. S. Himmell, New York), a paper identified with a watermark or printed impression is coated with casein or a similar material, much as in the case of paper for artistic printing. The identifying characteristic, in this case, can be seen only by transmitted light. The paper may be imprinted or written upon without further preparation. It is particularly recommended for use in printing trademarks. Producer and consumer could agree on the colored layer, thus increasing the protection against counterfeits.

Trade mark violations and violations of other commercial rights are actually frequent, most recently on the part of Japan, with the result that an "Information Center for Protection of Commercial Rights in Japan" has been set up at the German Industrial Center, Berlin W 35, Tirpitzufer 56. This Center collects and verifies complaints brought by German industrial and commercial firms, initiates exchanges of information among interested firms, and protects German rights insofar as possible.

2. By varying the thickness of paper layers.

Certain imitation watermarks are produced by varying the thickness in paper layers in which the material is distributed evenly. These may be distinguished from genuine watermarks by steeping them in an approximately 18% solution of soda lye. Imitation watermarks will disappear, while true watermarks will not. The former could be produced in the following ways for example.

(a) By pressing with rollers to which rubber letters, figures, drawings, etc, have been of fixed -- either the top roller of the wet press or the first dry cylinder of the paper-making machine -- so long as the paper is not yet dry, see US patents 711,815 and

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717,799, (E. R. and O. F. Behrend, of Erie); the very simple apparatus needed to produce such "spur" watermarks is furnished also by German manufacturers.

(b) By introducing relief during calendering; see W. Kleinewefers, Die Gaufrage [Goffering], pages 95-96.

(c) By placing the sheets between plates, and pressing in a roller press or a sheet press -- that is, during plate-glazing or web-glazing.

Many forms of imitation watermarks are produced these days by pressure, and there is a considerable number of processes devoted to the production of shapes to be impressed. They are now largely without practical interest, and are not further described here (see bibliography in Albert's Lexikon der graph. Techniken [Lexicon of the Graphic Techniques], page 152. For photographic filigree printing, a watermark printing device using gelatin or the like, see German patent No 7,120 in the name of Werner und Schumann, Berlin Phot. Korresp. [Photographic Correspondence], 1880, pages 188 and 220; and Phot. Archiv [Photographic Archives], 1883, page 110.)

3. By elevations and depressions in the paper. This is goffering or stamping, used primarily in certain check-writing devices, and perhaps never on unprinted or unwritten paper stock. Embossing is also much used on deeds, stock certificates, checks, passports, and other negotiable papers.

B. I. b. With a substance extraneous to the composition of the paper. Such substances may be colored or colorless - for instance, they may render the paper stock transparent. They may be of fibrous, thready, or other material. In general, the protective value of this method is unsatisfactory, but it can be

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improved by combining the separate processes, particularly by adding indirect recognition methods -- which will be dealt with later. The processes mentioned here are in many cases combinations, but for the sake of simplicity we shall describe them as a whole. They can also be used with matched-pieces authentication systems, which often affords a high degree of security.

There are several processes for guarantying authenticity which are carried out on the paper-making machine and which, from the standpoint of paper manufacture, should be discussed here.

1. Safety paper with inlaid threads. A degree of technical proficiency has been reached in their production that makes their falsification particularly difficult.

At first, woven pieces or individual threads of fibrous material were introduced into the pulp while it was running onto the mould, so that felting took place. The threads are imperceptible on the surface of the paper, as very fine gauge thread is used.

The threads may be laid longitudinally, transversely, or both, or at angles to one another. Transverse threads are inserted by a patented automatic weaving apparatus which handles from 1-50 spools simultaneously. The angle formed at the intersection of the transverse with the longitudinal threads can be varied by altering the number of spools used, the distance between them, and the speed of the spools or of the pulp web, and offers another guaranty -- though an inadequate one -- for the authenticity of the given paper.

According to German patent No 341,970 in the name of H. Thomassen, Heelsum, Holland, one or more threads are injected into the pulp in crooked lines. The injecting device moves up and down,

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placing the threads nearer or farther from the surface of the paper. Thus they are more or less visible by reflected light. The effect is impossible to produce by pasting threads between two thin sheets of paper -- as has been attempted.

The threads are usually injected into the pulp above the mould of the paper-making machine by means of a small glass tube, funnel-shaped at one end and bent at the other to guide the thread in the direction the pulp is moving (Figure 3). The thread may be colored and of various materials, for instance cotton, silk or linen; or of thin, ductile metal. A number of threads lying more or less parallel may be inserted into the web simultaneously.

The position of the injector in the pulp determines whether or not the thread will be in the middle of the paper thickness. An up-and-down motion of the injector produces a wave form, while a circular motion vertical to the direction in which the pulp is moving produces a spiral form inside the paper.

It is alleged, in the above-mentioned patent, that this invention assures the citizenry that without access to a complete paper-making machine it will be impossible to counterfeit the raw material for banknotes, checks, etc -- the paper stock -- without its spuriousness being readily apparent to everyone, including persons with little knowledge of the subject.

A paper with inlaid threads is readily identified by the layman by tearing away a tiny corner of the paper at a place where the thread emerges. Thereupon the manner in which the paper is felted around the thread will become readily apparent.

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The system of using thread inlays is used to mark the genuineness of the bank notes of the German Reich. Each denomination has threads of a special color:

10-mark Reichsbank note -- thread inlay is colored purple

20-mark Reichsbank note -- thread inlay is colored purple

50-mark Reichsbank note -- thread inlay is colored green

100-mark Reichsbank note -- thread inlay is colored mixed purple and green

1000-mark Reichsbank note -- thread inlay is colored mixed orange ~~red and green~~

It should be noted further that forgers have imitated the thread inlays of the Reichsbank notes by printing or drawing, or by affixing fibers or hairs by pressure or with adhesives. As pointed out above, these forgeries are rather easily detected.

It would of course be possible to choose a color for the inlaid threads that would give further easily identifiable marks of authenticity, particularly by indirect recognition methods. For example, it would be possible to use a dye which leaves a special color when burnt, such as ultramarine, Prussian blue, etc, or other dyes distinguishable by thermochromic or other chemical or physical reactions.

2. The granite papers are those which contain individual dyed threads or fibers visible to the eye. Regarding their fabrication see particularly the book by J. Erfurt, Das Faerben des Papierstoffs, [The Dyeing of Pulp]. It contains numerous patterns produced with the widest variety of threads. The paper is usually made by mixing dyed threads or fibers with the paper pulp.

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Granite papers have long been suggested for protective purposes. The oldest process of the kind is probably covered by German patent No 22573, (Eduard Musil, of Neusiedl, near Vienna). Yellow-dyed fibers are added to the almost completely mixed pulp in the pulp engine. When the fibers are albuminous, or contain albuminous matter, such as wool (xanthoproteins are formed), soap, feathers, hair, jute, raw linen, raw flax, etc, they are dyed with nitric acid. It is desirable to dye the fibers as deep a color as possible, but as the acid dye tends to consume them the amount of concentration in the solution must balance the 2 considerations. Granite papers, especially those with yellow dyed fibers, also offer some protection against reproduction by photographic processes.

German patent No 244,479, by L. Zeyen, of Raguhn (Anhalt), describes a special apparatus for the manufacture of granite safety paper composed of 2 layers of paper, couched together in the paper-making machine with the fibers embedded between them. The characteristic feature of the apparatus is a continuously revolving, perforated hollow drum which sprinkles the fibers onto the pulp on the horizontal wire mesh of the machine on which the lower layer of paper is being formed, at a point in the process before the upper layer, coming from a rotary-mesh machine above, joins the lower. Holes in the drum can be closed off by means of longitudinal strips and ring bands to distribute fibers where wanted, either in longitudinal or transverse stripes.

Such a paper is relatively easy to imitate. Two sheets of paper could be very lightly coated with adhesive, the fibers distributed as desired -- type, color, distribution, and size -- and the sheets pressed together and dried.

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Granite papers are used in Swiss postage stamps and in the Belgian mineral-water tax stamps. They are effectively used in combination with chemical protective measures (q.v.).

3. Papars inlaid with larger, macroscopic, easily visible, non fibrous particles.

German patent No 61460, by J. Macdonaugh, of New York, uses small bits of paper or similar material, cut or punched out in various shapes, which are so mixed with the pulp that the finished paper is completely or partially interspersed with them. The paper bits may be of the same or a different color as the paper, or different, and may have the same or different shapes.

The bits may be mixed with the pulp either in the stuff-box, just before the pulp goes onto the wire mesh, or scattered over the pulp -- regularly or in a pattern -- after it is already on the mesh. In the latter case it should be borne in mind that such patterns are most effective when visible on both sides of the finished paper.

A suitable device consists, for example, of a tube which is connected to a reservoir and is curved in the direction of the pulp flow. It injects the pulp mixed with the bits of paper, as desired, into the normal pulp feeding onto the wire mesh. It resembles the device pictured in Figure 3, except that the tube carries loaded pulp instead of fibers.

German patent No 214,838, by J. Gernaert, of Brussells, provides mathematical uniformity of the inlaid markings, not only in their shape but also in their position and distribution in or on the paper. This facilitates recognition of its genuineness.

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This is accomplished by embedding, between 2 partially wet layers of paper pulp, a thin, colorless or tinted inlay the full width of the mesh, in the proportions of the finished sheets of paper. The inlay may be cut or punched out, perforated, and printed with a repeating pattern on one or both sides. As will be readily understood, it is thus possible to manufacture any desired length and number of rolls or sheets of paper, all of which are identical in every respect.

The material for the inlays may be patterned or printed metal foil, gelatin or collodion membranes, or paper. The patterned inlays of gelatin collodion, or paper may in turn contain patterned metal foil which is affixed in the desired pattern before the inlays enter the pulp. This is the only way such extraordinarily thin metal foil flakes can be distributed regularly in the paper pulp; mere sprinkling will not produce uniformity. The carrier material may be such that it dissolves on contact with the water in the pulp and becomes invisible in the finished paper, leaving visible only the uniformly distributed bits of metal foil. Gelatin or collodion membrance can be used for this effect.

The paper stock may furthermore bear a watermark or be perforated. In the latter case the metal or other inlays can be exposed at predetermined points.

The finished paper, too, can be imprinted in such a way that the printed pattern and color complement and complete the color and pattern of the inlays.

As it was found that the bond between these semimoist paper webs was not satisfactory, they were bonded with an insoluble glue.

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The inlays in these papers consist of a printed and perhaps perforated material with a predetermined shrinkage factor which depends on the nature and water content of the adhesive used. However, it is difficult to maintain a constant shrinkage factor.

German patent No 487,824, by J. Gernaert, Brussells, avoids these difficulties by using an inlay of exceedingly thin paper (perhaps of a weight of 10 g per sq m), printed and perforated as desired, bonded to the outer paper layers by means of a glue (with formaldehyde) which becomes insoluble. Thus an inseparable unit results, with markings that remain in mathematically exact distribution. The triple sheet (Triplexblatt) made in this way then is moistened on both sides with water and glycerine, and is run through calenders, supercalenders, web-glazing machines, etc, to make it supple.

It may be doubted whether a paper fashioned in this way really offers any real protection against imitations. After reproducing the desired inlay design on tissue paper it is an easy matter to produce a similar or apparently quite identical paper by means of hot pressing, perhaps with a pressing iron, using gummed and dried or very lightly moistened paper -- without encountering the least difficulty from shrinkage.

A further development of German patent No 61,460, increasing the difficulties of imitating a paper similar to that produced under it, is German patent No 422,294, by doctor E. Fues of Hanau on the Main and the firm of Giesecke and Devrient, the Leipzig Typographical Institute. In this process, the material to be added to the pulp or the paper being formed on the wire mesh consists of bits of paper, celluloid, silk, etc, which are imprinted distinctively while still in sheet form with a design composed of drawings, numerals, letters, etc, and then reduced to pulp or confetti and added to the pulp.

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Inlaid particles, in addition to being imprinted, can also be pretreated chemically or physically, for example they may be mercerized, parchmentized, viscosed, paraffined, lacquered, metallized, etc.

All these additions result in a more or less coarse surface structure in the finished paper which interferes with subsequent imprinting by whatever method. Even offset would present difficulties. Bits of metal or lacquered paper, for instance, which absorb little or no printer's ink, would reproduce the details of a hatching or other protective design very unsatisfactorily. Therefore it is doubtful whether this class of papers will ever be generally used for the purpose.

But the following safety paper does not have the disadvantage of excessively irregular thickness. It is the safety paper produced by the Archimedes Company for the Development of Inventions, Ltd., of Prague, under German patent No 388,099. Tiny bits of metal of the thickness of gold leaf are sprinkled on the web of paper in formation before it arrives at the dandy roll which presses the platelets into the paper in accordance with the design on the dandy roll, so that the finished paper acquires a quite unusual and distinctive appearance.

Gold, which has the greatest malleability of all metals, of course can be rolled out to sheets 1/12,000 mm thick. Thus platelets of gold are much thinner than paper fibers, and there is no danger that paper so produced will present any surface irregularities. However if the platelets are too large, there will still be difficulties with irregular surface absorption of ink. In this connection

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it may be noted that it might be possible, utilizing processes developed in the last few years for metallizing paper, etc, to metallize all or part of the surfaces of individual fibers by means of cathodized dusts, and use the fibers in safety papers. Schoop's metal-spray process has also been suggested for use in making safety papers.

Other, preferably nonoxydizing, cheaper metals -- tin or aluminum foil, for example -- could also be used in the above-mentioned process. However, these hold to the paper much less firmly, and cannot be rolled so thin as gold foil. Gold particles, on the other hand, are very expensive.

Finally it is to be noted that shiny metal particles in paper render photographic reproduction of a document, check, etc, more difficult -- another advantage, but one not stated in the above-mentioned patent.

In the processes described immediately above, the protective effect is dependent upon the performance of a paper-making machine. This is also true of the following.

German patent No 412,381, issued to the paper mill of the Koeslin A. G., in Koeslin, Pomerania, covers a safety paper made of 2 complete webs of paper couched together in the machine, with partial webs of material between them coming from a third, partially covered wire mesh.

It differs from the papers with inlay designs applied by flotation, or those with a layer of finished paper inserted between 2 webs, in that the middle layer is made up of one or more partial webs, and all 3 courses are manufactured simultaneously.

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This safety paper offers greater security against imitation, but whether a paper-making machine is essential to its manufacture -- as is claimed in the patent -- is doubtful. Such a paper could not be imitated by cementing layers of paper together, as the fusion of the different webs would not take place as it does when all 3 are being manufactured simultaneously. And the different appearance of a cemented paper with inlaid paper bits would be obvious even to an untrained observer. However, similar papers could perhaps be made by hand.

According to [German] supplementary patent No 413,216 one or more partial webs can be added on top of the full web, but not superimposed on each other.

The preceding principles are partially applicable to pasteboard.

An identity card composed of a layer of pasteboard glued between 2 layers of paper is very easily imitated by hand work. Because of the layers of adhesive they are, furthermore, very stiff, inelastic, and brittle.

The identity card produced under German patent No 243,972, issued to O. Dittmar of Arnsberg, Westphalia, is made of several layers of pasteboard, but it differs from the usual multiple-layer pasteboard in that the interior layers differ from one another.

This differentiation among the inner layers -- as many of them as may be desired -- creates a readily identifiable characteristic. A counterfeit card would only have to be torn or cut at a slight angle in order to reveal the difference.

According to the patent it is impossible to imitate the above-mentioned card by pasting various layers together, because

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the finished cards would be so stiff and brittle that there would be no difficulty in distinguishing them from the machine-couched product. This claim may be doubted, however, as an adequate imitation could be produced with especially flexible glues, or by pressing together several layers of wet paper by hand and possibly sizing them with a very weak glue.

4. Papers with any complicated colored pattern, such as marbled and spattered paper, etc. There is a vast number of processes in this field for producing useful safety papers. Only those which have been specifically proposed for safety paper are mentioned here.

German patent No 283752, (Max Luettich Company of Weimar), protects an invention which concerns the production of a paper stock for documents, postage, trading, advertising stamps, and the like, which makes imitation difficult.

The basis of the invention is the application of coloring matter into the web as it leaves the couch rolls, before reaching the dry side of the machine. A ruling device here applies the color in straight, zigzag, broken, or waved lines, or in special designs. The coloring matter soaks into and runs into the wet paper web. As a result the finished paper has smudged, indistinct markings instead of the usual sharp ones. The markings may appear on one side of the paper only or may be allowed to soak all the way through and show on both sides. The color may be applied by rollers running longitudinally or transversely to the direction of the web, or a small wheel working somewhat like a weaver's shuttle may be made to run back and forth across the web with various pattern possibilities. Compare also US patent No 1652042.

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Instead of applying the color to the web directly after it leaves the couch rolls, any other point in the process may be chosen so long as the paper is still damp enough to absorb the color and allow it to run more or less.

However, regardless of the claims made in this patent, lines which appear to have run, or bled can be produced on dry paper by adding wetting agents like alcohol, gall, Nekal, or the like to watery printing inks. Thus the colors will run on dry paper, and the paper described in the patent can by easily imitated.

Then, too, the spurious paper could be imprinted with watery inks after being moistened, or when unsized, and then sized, to produce an effect similar to that in German patent No 283752. In any case, paper produced under this patent can scarcely be called safe, so far as security of identification is concerned.

A special variation of German patent No 487994, described elsewhere, consists in washing a dyed paper with chemicals, at preselected points, to produce a deepening of the color of any desired imprint wherever the wash is applied. Without sacrificing the general dye's advantage of signalling attempted erasures, the security of the paper stock against counterfeiting is considerably increased. Dyes like Patent blue V, nigrosine, and others which react to chemicals such as acids, alkalis, or chlorine, are used.

This is a combined technique, combining protection of the authenticity of the paper stock with protection against mechanical and chemical erasure.

5. Papers which have been imprinted in patterns with substances which render the stock transparent. In this manner effects

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like that of a watermark can be attained. These papers are discussed below among the safety printing techniques.

B. II. The indirectly perceptible patterned identifying characteristics may be recognized by physical or chemical means.

B. IIa. The characteristics recognizable by physical means may be divided as follows.

1. Marks which can be identified by mechanical means. To these belong, for example, papers which display visible changes when rubbed with specially prepared substances. These were discussed above among the protective chemical techniques. Furthermore, mechanical properties such as the length of tear and the wrinkle index mark the genuineness of a paper stock. Bank note papers, for example, have a tear-length of 6,000 m, and a wrinkle count of 2,000 -- neither of which is attainable by many paper mills. To ascertain these characteristics, the usual test apparatus must be employed. As the usual tests destroy the paper, they are not practicable for banks, where subjective tests must suffice.

2. Marks which can be identified by thermal means. Many substances have the property of changing color when heated. These color changes may be permanent or reversible. The latter offer an advantage for protective technology in that the document in question is not permanently altered, and the existence of the identifying characteristic is not revealed. One of the materials used for this purpose is bi-iodide of mercury which has a beautiful red color which turns black upon heating. It is stable in an oily medium, but rather unstable in watery media.

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Yellow silver-mercury bi-iodide becomes red at 100° C, while red copper-mercury iodide turns brown at 60-70° C. These colors are effectively protected by coating them with varnish.

Many other substances have thermochromic reactions, including certain ethylene derivatives (see E. Beckmann and H. Corte, Ber. [Reports] 86, 1943, pages 39-43).

Cobalt salts, especially the cobalt halogenides, change to a beautiful blue when heated, returning slowly to their original colors. White paper may be impregnated with cobalt chloride and left virtually colorless. When heated with a hot iron, match, etc, the affected portion turns a beautiful sky blue. The principle is of course also used in secret writing.

The fact that many substances leave an ash of a certain color when burned may likewise be used in testing the authenticity of paper stock, and seems to be in use for Swedish bank notes. Ultramarine leaves a blue ash, Prussian blue a brown one, etc. The method is not to be recommended, as a portion of the document to be tested must be destroyed.

3. Marks which can be identified by optical means.

aa. Photographically.

Identifying characteristics may be identified photographically in many ways. Every printed document, when photographed on suitable plates, produces a characteristic picture which is entirely dependent on the nature of the dyestuffs present in the paper and ink. With specially prepared plates or special filters different pictures can be produced of the same document.

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Invisible or colorless substances which on a photographic plate are reproduced in black -- for example quinine -- may also be used.

Photography is also important in the photographic safety system developed according to Koegel's principle of the maximal-multiple accident. Microphotography is particularly important in this connection.

(See Professor Koegel's article in Photogr. Korrespondenz [Photographic Correspondence], Vol 63, No 1, and his book Die Unsichtbaren Strahlen im Dienste der Kriminalistik [The Invisible Rays in the Service of Criminology], page 154).

Koegel's process for assuring authenticity probably represents the most complete system of this kind to date. With an atomizer (or spray gun), minute droplets of various liquid dyes (visible or invisible) are sprayed on a sheet of paper. Depending on the way the paper has been treated, a certain number of droplets will overlie each other. Their shape, position, distribution, and color combination are determined by an extraordinary number of accidents. An entire roll of paper could be sprayed without repeating a pattern. Microphotographs are made of a few points. Invisible droplets are made visible with suitable reagents, or photographed in ultraviolet light or other special rays. The microphotographs are retained as controls and the paper may be provided with a network of coordinates to facilitate subsequent location of the control points. Signatures, numerals, fingerprints, etc, may be affixed before or after the spraying.

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The object in question may also have portions punched out of it which them fit together like lock and key. The addressee receives one portion, the other is retained by the office. This latter type of protective technique, the so-called "matching pieces" system -- is particularly suited to government bonds, lottery tickets, and also for cashier's checks, stock coupons, contracts, and the like. However, photography is not necessary with "matching pieces."

Koegel's system is primarily intended to demonstrate the authenticity of works of art, although it could be adapted to many other uses.

Imitation of a document so protected, by means of 3-color photoengraving or other mechanical processes, will always appear much coarser than the original. A really exact imitation may be considered completely impossible. Photoengraving and half-tone may of course be used instead of sprayed color to form a pattern.

Albert's registration system (German patent No 364390), primarily for artistic paintings, should also be noted. It consists principally in microphotographing certain points on a painting and registering the photographs. Koegel and others have characterized this system as too uncertain, as the surface of an oil painting changes with time (crackling, displacement).

Unfortunately, the photographic methods for recognition of genuineness are much too complicated and expensive for practical protective purposes.

bb. Microscopically.

This involves adding to the paper pulp certain extraneous materials which have a distinctive microscopic appearance.

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When examined under a microscope the distinctive additions appear, thereby proving that the paper is genuine, or at least the product of a given manufacturer.

German patent No 399671 (Georges Fournier, Paris), describes such a process for which the spores of plants (lycopods -- or in general all cryptogams or mosses), or certain crystalline mineral powders and the like are well suited for this purpose. Mixing various microscopic particles makes it possible to develop an infinite number of combinations. Furthermore, the particles, which are added to the pulp immediately before it is made into paper, may be dyed with methylene blue, methylene green, etc. The color should be stable to light in the given combination, and this stability results only in special cases, such as when viridian is dyed with methylene blue. The density, or number of particles per unit of surface area, may also be used as a means of identification. The patent claims that in view of the technical difficulties in effecting identical configurations, either in nature or in the coloration, it is impossible to duplicate exactly a given paper made by this process. Thus it is claimed the invention provides certainty that counterfeiting a series of bank notes or other negotiable instruments is impossible; and that if imitation is attempted, the counterfeit can be instantly detected whenever a sale is made or a bank note cashed. This might be true in the case of an extremely complicated combination of colors and particles, and if a complete microscopic examination is made. But these demands generally cannot be made of the people who cash bank notes, etc. Furthermore, microscopes are expensive instruments, and it takes a certain amount of training before they can be used effectively. But if the jeweler's pocket lens replaces the microscope in the process, security is diminished

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and the possibilities of counterfeiting considerably increased, because with the pocket lens the characteristics of the paper additives can be seen only dimly or not at all, and other additives might more easily be substituted.

Lycopodium, or witches' meal -- the ripe spores of Lycopodium clavatum, Linn., or club moss -- is a fluffy yellow powder which is difficult to wet with water. Under the microscope the individual spores appear as translucent, oil-filled tetrahedrons which are almost of equal size. The diameter is 30-35 μ , and one of the surfaces is slightly convex. The surfaces are also covered with a raised network having 5-6 cornered meshes. Potato flour particles are of about the same order of magnitude but have smooth surfaces.

Another microscopic identification mark is infusorial earth or kieselgur. It has also been suggested as a distinctive additive for sealing wax.

Polariscopy gives definitive information about the crystalline structure of a substance only under certain conditions, but it can be used for microscopic determination of authenticity if those conditions are met. Particles must be no smaller than about 5 μ with a refraction index not greater than 1.7.

Paper fillers like lenzine kaolin, spar, chalk, quartz powder, asbestos, or talc are anisotropic, exhibiting distinctly luminous particles under the polarization microscope.

Calcium tartrate, magnesium ammonium phosphate, and manganese oxalate have more specific characteristics. The latter exhibits lively colors under polarized light. Manganese salts (q.v.) are

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also used as forgery indicators. A colored material is nickel dimethylglyoxine composed of red dichroic needles.

Botany and mineralogy offer further possibilities, and microchemical analysis offers valuable suggestions. For security purposes, however, the discovery of new or as yet unpublished substances would be preferable.

The microscopic particles employed may be further differentiated either by their covering or glazing properties. Those which glaze exhibit their proper color by transmitted light; whereas covering or opaque substances always appear black.

Microscopic methods of recognition identification are out of the question for most practical purposes. They are too complicated and the object to be investigated must be damaged or destroyed.

cc. Marks which can be identified by invisible rays.

Most important among the invisible or electromagnetic waves for our purposes are those with wavelengths shorter than those in the visible spectrum (400-700 $m\mu$) -- particularly ultraviolet (wavelength 15-400 $m\mu$) and in lesser measure x-rays (0.01-1.5 $m\mu$) and k-rays (0.005-0.002 $m\mu$).

The usefulness of ultraviolet rays lies in their peculiar capacity of bringing out the characteristic fluorescence of substances. Fluorescent substances are those which emit radiation when under the influence of light. A great many substances possess this property, but in ordinary visible light it is only minimally effective, if at all, because it is lost in the reflected light. To make the fluorescence plainly visible a light source is used

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which emits no visible radiation but only invisible light. Particularly suitable for this procedure is ultraviolet light with a wavelength of between 300-400 $m\mu$, like that produced by the quartz lamp. When a bank note is placed before such a lamp in a dark room, the room remains dark but the paper glows more or less brightly, as do most of the imprinted inks -- and in colors different from those seen by visible light. The bank note thus acquires an appearance quite different from its "natural" appearance. Even the best counterfeit bank notes or stock certificates betray themselves in the dark ultraviolet light by differences in paper stock, inks, watermarks -- those printed with oily inks are easily differentiated from real watermarks -- as against genuine examples. Ultraviolet is already widely used in banks, for testing counterfeit cigaret tax stamps, and particularly for postage stamps. (See Mueller "Ultraviolet Rays as Tools in Testing Postage Stamps," an article in Die Postmarke, [The Postage Stamp], No 120, 1926, Vienna.

Many substances have particularly strong fluorescent colors. These can be used in the manufacture of fluorescent safety paper or designs, especially if they are colorless and invisible by visible light. Materials that fluoresce particularly strongly are quinine, aesculine, and the uranitic dyes which fluoresce very strongly even when extremely dilute; also rhodamine 6 G D and flavophosphine 4 G concentrate, and many other dyestuffs (B. Schulze and F. Goethel, "Fluorescent Microscopic Studies of Materials for Paper Fibers," article in Papierfabrikant [The Paper Manufacturer], 1934, page 110.)

According to German patent No 497037, (I. G. Farben Company), a safety paper with a distinctive characteristic is manufactured by incorporating into it -- preferably in patterns -- several substances

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which fluoresce in at least 2 different colors under ultraviolet or other invisible rays. Ordinary papers can be made with only one additive, and in such minute quantities that there is no appreciable effect upon the structure of the paper, which need not be completely covered.

Aside from the well-known inorganic substances like barium-platinum cyanide, zinc sulfide, uranium salts, etc, numerous organic materials are excellent for the purpose, especially certain higher hydrocarbons like anthracene and its derivatives, also salicylic acid salts, and other aromatic hydroxy compounds. According to the patent, the addition of only 0.5 kg of finely divided anthracene to 100 kg dry weight of paper pulp produces an extraordinarily vivid violet fluorescence when the paper is placed under ultraviolet light.

Sodium salicylate	produces a vivid blue-violet fluorescence.
Pyrene	produces a vivid blue fluorescence.
Chlorbenzanthrone	produces a vivid yellow fluorescence.

From 10-20 g of sodium salicylate per 1 of printer's ink suffice. The fluorescent materials can also be applied to the still wet paper web in the machine.

A particular advantage of these identification methods using fluorescence is that the marking may be quite unnoticeable, or completely invisible.

For the use of ultraviolet rays in the detection of content forgery see the chapter on protection against content forgery.

Despite its great advantages, dark ultraviolet light must not be overestimated in protection technology, for if a forger should

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succeed in replacing a genuine document with an imitation, or in exactly imitating an original -- with the help of the ultraviolet lamp -- his fraud would be only the more successful. Ultraviolet does not solve the problem of making counterfeiting and forgery impossible, and by no means renders indispensable the other technical protective measures available to the paper and printing industries indispensable.

The high price of quartz lamps -- associated with the technical difficulty of making quartz glass-stands in the way of their wide distribution. According to the magazine Der Naturforscher [The Naturalist], Vol 11, 1934, pages 218-219, a new, cheaper ultraviolet lamp with phosphate glass is now on the market.

Also to be mentioned is the Callophan apparatus named after its inventor, A. Callo, with which dark ultraviolet light can be obtained from daylight, making the quartz lamp superfluous (W. Halthof Z. anal. Chemie [Journal of Analytical Chemistry], Vol 91, 1933, pages 263-266). According to Spater (Kunststoffe [Synthetic Products], Vol 22, 1932, pages 249-250), it can be used to identify fibers; thus, the utility of this inexpensive apparatus for protection purposes can hardly be questioned.

X-rays as well as ultraviolet rays stimulate fluorescence, but from a technical protective point of view are less significant in this respect than the latter. More important is their ability to penetrate most substances more or less completely. Substances containing heavy metals are penetrated least. According to German patent No 337818, awarded to the Veifa company of Frankfurt-Aschaffenburg, and doctor Stirm of Frankfort on the Main, bank notes checks, and the like, are imprinted with designs, morse code symbols,

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or written characters using a colorless solution of a material, such as a salt of one of the heavy metals, which strongly absorbs x-rays. Nothing is visible to the eye, but the printed symbols show up distinctly on the fluoroscope or photographic plate when the document is penetrated by x-rays.

In order to imitate a document identified in this way, a forger first would have to possess some foreknowledge of this form of identification, but even with this knowledge, he would have to know exactly how the ink was compounded, before being able to produce his counterfeit. If the solution is a mixture of various salts -- an effective procedure -- it becomes more difficult to analyze it. However, insofar as inorganic salts are concerned, a qualitative determination is usually possible by microchemical analysis.

X-ray photography is of course one of the most valuable methods for identifying works of art and the like. By this process layers of color beneath the surface of the picture are made photographically visible.

X-ray photography in many cases circumvents photo-mechanical protection measures (q.v.).

Cathode rays likewise produce fluorescence in a number of substances. The fluorescence may disappear again under further cathode irradiation, but, once evoked by cathode rays, the fluorescence can be further produced by ultraviolet irradiation -- even though the substance originally was not fluorescent in ultraviolet. Herein lies a further possibility for protective techniques.

dd. Identification marks which glow in the dark. These can be produced with the aid of phosphorescent substances and are

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based on the same principle as clocks that glow in the dark. The high price of the raw materials, and often their poisonous nature, usually prohibits their use.

4. Magnetically identifiable marks, whose presence can be established by means of an ordinary magnet or an electromagnet.

According to German patent No 416302, (M. Reinheimer, Breslau), 10 g of finely powdered, nickeliferous iron are added to every 400 g of the paper pulp in the beater, the pulp consisting of cellulose, kaolin, annaline (a kind of gypsum), ultramarine blue, and sizing. The resulting paper reacts to an electromagnets.

Nickelizing the iron serves to prevent rusting, as complete oxidation would destroy its magnetism. The value of such a safety paper appears questionable. Pulverized iron and nickel are to be found in shops, and furthermore can be easily produced with a file. Likewise, magnetic powders are easily obtained from rustless iron alloys, whereupon it would be easy for a paper-maker to produce a magnetic paper. It would also suffice to press such powders onto the paper, or even to imprint it with an undercoat of strong varnish -- such as bronzing varnish -- and then sprinkle a magnetic powder over it. Thus it would be possible for instance to treat a black imprint on a bank note, check, or the like, with just such a varnish and then sprinkle it with an equally black iron powder.

The same inventor in German patent No 416303 has suggested the production of patterns resembling watermarks, etc, in nickelized iron dust on couched paper, still damp, covering the paper thus prepared with additional damp pulp and couching the whole together. The pattern is produced by means of a stencil and a bellows which

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sprays the dust. Seen from above, a pattern resembling a watermark results on the paper. By transmitted light the pattern exhibits a 3-dimensional form.

5. Marks which can be identified by electrical means.

Safety papers can be impregnated with substances which produce a specific color, for instance, when in contact with an electric current. It appears that hitherto no patents have been granted for this process, specific ally for safety papers, but several safety papers (for instance those containing iodides) are so constituted that they can be used for electrical identification without further processing.

B. II. b. Papers which can be identified by chemical means have been discussed in A II above. This discussion also pertains directly to methods of ensuring genuineness by means of patterns, as the substances adapted to chemical assurance of authenticity may be associated with the paper either in a pattern or in uniform distribution.

Chapter III. Protection Against Content Forgery -- General Safeguards and Techniques in Paper-Making

Protection against content forgery is based primarily on the application of chemical and physical principles so that any attempt at forgery produces some obvious alteration in the document, which is easily recognizable -- at least to interested persons. The safeguard against content forgery does not necessarily have to be difficult to imitate, but difficulty of imitation substantially increases the safety of the document as a whole.

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Corresponding to the various forms of content forgery given in the chapter on forgery there are protective methods against each form. Often these protective methods provide safeguards against several or most of the possibilities of forgery. The more possibilities of forgery they exclude or render difficult, the more valuable they are from the point of view of protective technique.

We divide the methods of protection against content forgery as follows.

I. Safeguards against the removal of that portion of the paper which carries the inscription (mechanical erasure, splitting off, cutting out, etc).

II. Safeguards against the removal, alteration, or substitution of writing without removal of the portion of the paper which carries them (addition, covering over, bleaching with light, chemical bleaching). These individual protective processes, suitably combined with one another, can provide security against all possibilities of content forgery.

The patents in this field are often combined processes, and therefore many of them are discussed elsewhere, depending on their nature.

I. Safeguards against mechanical erasure may be achieved in the following ways.

1. The surface of the paper is made easy to damage mechanically, in order that damage may be plainly noticeable. This may be achieved by imprinting the paper with fine drawings, hatchings, patterns, pictures, etc. In case of mechanical erasure or perforation,

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the blank space left by the removal of the picture immediately becomes obvious, and the more complicated the drawing, the more difficult it is to repair the damage.

In place of regular drawings, irregular patterns produced by spattering, marblizing, etc, may also be useful. These are often much more difficult to repair than are uniform patterns. The latter can always be restored by cutting or splitting a corresponding piece out of another copy of the same document, such as another blank check. If a pattern like that in Koegel's process is used, according to the principle of maximal multiple accident, it will be impossible to restore; especially if invisible elements are used in the pattern, such as those which become visible in dark ultraviolet light.

Similar in principle to the protective methods mentioned directly above are the granite safety papers. One type is manufactured under German patent No 422374, (R. F. Liesegang, Frankfort on the Main), according to which dyed fibers are sprayed onto the paper while it is being formed on the wire mesh or at a later stage. Dyes sensitive to bleaching agents are used in the process. In case of mechanical erasure the sprayed fibers are removed, but they are rather easily imitated by a skillful draftsman. So this process cannot be considered very dependable. This holds true also for safety papers wholly or partially covered with hatchings. In many cases they fail in their purpose because the printed background is usually so resistant on normal paper that the handwriting can be wholly or partially removed without causing any immediately obvious damage to the undercoating. This is particularly the case when the writing has been done through carbon paper, a process which is very

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widely used today. Papers that are sensitive to mechanical erasure of any kind, such as those described in German patent No 497178 (see 2) would therefore be preferable.

Papers with surface coloration are also sensitive to mechanical erasure, and the less the layer penetrates the paper, the more sensitive it will be. Such safety papers are produced for example by passing finished, sized, paper webs through a dye solution which is subsequently squeezed out. Paper webs may also be imprinted or coated with dye solutions. To produce fancy multicolored papers dyes dissolved in water are furthermore applied to slightly moistened paper, left in contact for a time, and then washed off before the dyes are completely dry. The washing is done to avoid hard boundaries between colors and possible smearing of coloring materials not absorbed by the paper.

According to German patent No 487994 (I. G. Farben), a surface layer of the paper as thin as possible is dyed by passing a sized paper through a dye solution and then not wringing it out, as usual, with a pair of rollers, but by rinsing it off directly after the dyeing process. The paper thus produced, which has an extraordinarily thin surface layer and is colored differently from the rest of the paper stock, is a good safety paper because mechanical or chemical erasures, whose traces are difficult to remove, could be recognized immediately (see B I b4, under Protection of Authenticity.)

The safety papers with surface color are also sensitive to forgery with chemical agents if dyes sensitive to ink bleaching agents are chosen. But a correction is easily possible, for instance by recoloring papers whose entire surface is of a uniform color.

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Nor does the fact that mechanically erased areas behave differently -- ink marks run, watery colors soak in deeply -- constitute a hindrance to the skilled forger.

Surface-dyed papers in general should not have deep, dark colors which would interfere with the legibility of their contents. But the less the surface color differs from the color of the layer of paper underneath, the less obvious will be an erasure. Furthermore, colored papers are less desirable as writing paper than white paper. Therefore dark papers have been covered with light colors (British patent No 159740). In case of mechanical erasure, then, the surface color is removed and a dark spot appears, caused by the dark paper stock which has been uncovered. Such spots can easily be made to disappear by coloring over them. Here it would be better to use a coated, glossy paper on which erasures can only be corrected with much more difficulty, if at all. Of course it is possible to produce glossy papers which are easy to write on with ink.

In place of a color coating a thin layer of paper is utilized in German patent No 303989 (doctor E. Haussmann, Berlin). If produced in the usual manner -- with aqueous binders -- it is highly sensitive to mechanical erasure, and absorbs ink readily. It is produced by couching on the paper machine. A very thin, but colored, paper layer is couched together with other paper layers in US patent No 1910568 (T. J. Snyder, Chicago) (see page 83).

To protect written documents against erasure of falsification of the handwriting, it has also been suggested that a material capable of being engraved -- such as celluloid, gelatin, or the like -- be used on a base of ordinary paper. Numerals, etc, could then be entered with a stylus, pen, or pencil. An alteration of

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the numerals so written could only succeed if the engraved substance and the binding medium -- such as lacquer, resin or the like -- which held it to the paper, were removed and a new coating applied. But a safeguard could be employed against this, for instance, by coating the lacquer coat with an overprint composed of coal-tar dyestuffs which are soluble in all the solvents that dissolve lacquer. Removal with a lacquer solvent would then no longer be possible without discoloring the paper at the affected spot, and another safeguard can be provided in advance to prevent the bleaching of this discoloration. Of course the lacquer layer could be removed by erasure, but against this procedure still another safeguard could be provided, perhaps by using differently colored layers or punches, or something similar, or by using an overprinting which is not resistant to erasing -- an overprinting, that is, which effects a smearing of the surface in case of erasure.

Goffering or relief-stamping also protects the paper against erasure and has been used in several check-writers.

In order to exclude the possibility of mechanical erasure of pencil or carbon script, doctor Paul Steuer, Berlin-Steglitz, has patented a process (German patent No 497178) which is based upon the use of weakly sized paper with long fibers. On such paper every attempt to remove an entry, wholly or partially, by means of mechanical erasing is signalized immediately by clearly visible damage to the surface of the paper.

The use of long fibers for safety papers was known previously, but was primarily used in the authentication of granite papers, etc, and not, as in the above-mentioned process, for protection against mechanical forgery.

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The patent envisages furthermore that these papers will be provided in the usual way with a printed background (hatchings) in order to increase still further the security against mechanical erasure.

The addition of suitable chemicals serves as protection against chemical erasure.

According to V. T. Bausch ("Safety Paper," Zahlungsverkehr und Bankbetrieb [Clearing House Operations and Bank Management], No 1, 1932, page 15) a paper such as the above is to be recommended for internal and bookkeeping transfers made by banks. These are usually written on carbon paper, a typewriter, or with ink. But for writing in ink (checks, hand-written documents, etc) such paper is out of the question, as long-fibered paper is not suited for pen and ink.

2. The paper is sized somewhat or rendered easily permeable so that writing in ink soaks deep into the paper or even through it. A mechanical erasure in this case is impossible without destroying most of the paper. The less the paper is sized the deeper the ink sinks into it. This offers added protection against mechanical erasure. But ink does not only sink into the paper but also spreads, so that the ink line assumes an indistinct, fringed appearance. This is avoided by German patent No 546627 (Snyder Document Protection Company, Chigago), which covers safety paper consisting of a basic layer (a, in Figure 6) and a top layer capable of being engraved. (b, in Figure 6.) The latter however is opaque and so thin that it is punctured when scratched (c, in Figure 6) while the basic layer is made of absorbent stock. This stock may consist of ordinary blotting paper, but the covering layer gives it a completely different

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appearance and a surface structure which is suitable for writing. The engravable covering layer may for instance be composed of casein.

When the cover layer is grooved by writing, the ink flows into the blotting paper, but the spreading of the ink in the blotting paper is imperceptible in the covering layer because of the latter's opacity. The writing therefore has a normal appearance. But any alteration of the script, for example by scratching away the covering layer, application of a new covering layer, and rewriting on the new cover, would be noticed immediately because of the difference in the extent to which the ink has spread through the basic layer.

Of course a forger could reproduce all the strokes of the writing on the back of the paper, so that alterations in the extent of the ink would no longer be perceptible.

The cover layer may be applied by means of a bath, or casein may be sprayed on, or applied in some other way, always keeping in mind that the absorptiveness of the basic layer must not be affected. The protective layer is so smooth that one can write on it just as well as on ordinary paper; yet it is so thin that the ordinary writing pen (d, in Figure 6), digs holes or slits wherever writing pressure is applied. The ink flows from the pen through these slits into the base layer (e, in Figure 6), spreads through it, and becomes visible even on the reverse, where the writing appears blurred and mirrored (Figure 5). (Figure 4 shows the signature, Figure 5 the same signature as seen from the back.)

Such paper may be considered to give complete protection against mechanical erasure, but it is not satisfactorily protected against chemical erasure (see page 89).

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The amount of sizing in the paper must not be too little to take care of the spreading of the ink and its possible effect on the legibility of the script (for example, on indorsements on the reverse side). Furthermore, a poorly sized paper usually is not easily written upon with a pen.

For complete protection of ink writing against mechanical erasure, one is not limited to the use of weakly sized papers. Wetting agents which cause the ink to penetrate the paper may be added to the ink; thus a diminution of the surface tension is introduced.

The surface tension of inks is frequently reduced for specific purposes, for instance for the manufacture of free flowing inks for fountain pens. In such a case, however, it is always a matter of a limited change, so that the ink still forms sharp outlines and does not penetrate through the paper. But if larger quantities of the agent which reduces the surface tension are added to the ink solution, the ink will penetrate much deeper into the paper or under certain conditions will soak through it completely, so that written characters will appear on the reverse side. Written characters produced in this manner are completely protected against mechanical erasing, as a hole would have to be erased in the paper in order to remove them. But such characters are far better protected from chemical erasing as well, especially if the paper is impregnated with substances which act as corrosives upon the ink, for the removal of deeply penetrating ink marks would release more and more of the corrosive, producing longer and deeper action of the same, whereby even the paper itself would be increasingly involved.

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Among the substances which reduce the surface tension of inks are the methyl and ethyl alcohols, formic acid, acetic acid, ammoniac, acetone, and many other organic and inorganic substances. These substances evaporate from the ink simultaneously with the water, or -- like the acids -- strongly attack steel pens. From the standpoint of protection, those surface-tension-reducing agents (also called wetting agents, or detergents) are preferable which do not evaporate and which retain their effectiveness in the dried ink. These latter in general cause a wider spreading of any corrosives applied to the dried ink marks and thus assist in the formation of a larger reaction area when they are used upon paper containing ink corrosives. This makes it considerably more difficult for a forger to remove individual ink marks or lines with corrosives. Many such corrosives have come on the market in recent years, including the Nekals of the I. G. Farben Company, and others. Soaps also belong to the detergents. With chloride of lime the soaps form calcium emulsions which are insoluble in water and difficult to remove from paper. In addition they protect ink writing even better against corrosives. But, in contrast to the Nekals, soaps will not mix with all dyes, especially not with dyes containing ions of heavy metals. Soaps also tend to alter the colors of certain dyestuffs because of their alkaline reaction.

The Nekals and other detergents may be utilized to prepare isolated areas or the whole surface of a paper, so that it absorbs ink in these areas like unsized paper. Alcohol and ether are well suited for this purpose. Blank checks for example might be treated with alcohol, Nekal, etc, in the areas where the amount is to be written, so that ordinary ink soaks through to the reverse side and mechanical erasure is impossible.

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A paper also may be treated with Nekal or other detergents so that ordinary ink will run or spread. One would write on it with an ink containing a Nekal additive which adjusts the surface tension of the ink to that of the paper. As a result it will write without running or spreading. But Nekal is easily removed from paper by water, and the paper would therefore have to be protected simultaneously against treatment with water. This could be done with solvent indicators such as watercolor ink or aniline oil inks or, preferably, the paper could be desized with alcohol instead of Nekal. Compare also US patent No 869823. Only papers sized with resinous sizing can be desized with alcohol.

Many additional combinations of a similar kind should be valuable for protective techniques.

3. The characters are punched out of the paper, for instance in perforated form. This process is used in check writers (Protektograph), and protects completely against mechanical erasure (see chapter on protective methods -- protection of handwriting).

4. An actual erasure is detected by chemical or physical means or the methods for investigating forged papers are used as protective methods. In this case it is not necessary to provide the paper with any special protective properties. But this does not render superfluous the specific protective methods and safety papers, as forgers naturally can also utilize criminological investigation methods and treat forged notes or documents in such a way that these investigative methods would not detect the forgery. However, most of the criminological investigative methods are practically useless as protective techniques as they are much too complicated and often undependable. This is true above all of the chemical methods

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(iodine fumes, etc), the photographic methods, and spectrum analysis. But the invisible ultraviolet rays prove very simple and useful for these purposes. However, even this method does not work against mechanical erasures under certain conditions. Thus, C. A. Mitchell (Analyst, Vol 58, 1933, pages 532-3) has established the fact that pencil marks can be erased without any traces of the erasure being revealed upon exposure to ultraviolet light. Only when the erasure goes so deep that the paper becomes transparent does the abraded area appear as a dark spot in ultraviolet light. But, depending on the nature of the inks used, mechanically or chemically erased ink writing can become very clearly apparent, in ultraviolet light.

Especially suited for the detection of mechanical erasures is microscopic inspection under oblique lighting (see Koegel, Photogr. Korrespondenz, No 762, 1928).

In the preceding lines it was primarily the protective measures against mechanical erasure (erasing and splitting off) which were discussed. Most of these are also suitable for making it difficult or impossible to cut writings out of documents and replacing them by others. A very good safeguard against this little-used forger's procedure is offered by the previously mentioned sprinkling of the paper with visible or invisible substances (or those which fluoresce in ultraviolet light). Also a forger's use of pasted patches, or another kind of paper, is usually perceptible by virtue of its differing fluorescence under ultraviolet.

Forgery by addition -- that is, the alteration of writings without previous erasure, by the addition of writing -- is not common on checks, notes, etc, because it is usually impossible. For example,

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on checks the amount is written out in words as well as in figures. The amount of difficulty involved in attempting forgery by addition or rewriting depends on the language used.

Among the most important world languages English -- the language most-widely used in business -- offers especially simple opportunities for forgery by addition. For example, the word 8 (eight) can be changed to 80 (eighty) by the addition of a single letter. Many other similar examples could be given. And the best so-called safety paper offers no protection against forgery by addition. On the other hand, good or complete protection can be attained by using check writers; cryptograms, secret symbols, by punching symbols into the paper, by specifying the maximum amount, etc. Dark ultraviolet light here, too, constitutes one of the best testing tools, provided that the forged addition is not executed in the same ink or dye as the genuine writing -- in other words, provided that the added writing will fluoresce differently from the genuine. The genuine writing may also be protected against additions by covering it with a coat of lacquer or transparent adhesive paper. Or the areas of the paper surrounding the writing may be desized, for example with Nekal or similar detergents, and these detergents may be protected from dissolution by the use of solvent indicators.

The covering or masking of writing or erased areas is often practiced by forgers. To provide protection against this practice, most of those protective methods can be used which safeguard against mechanical erasure, that is, hatchings of fine lines, patterns, and guilloches, printed background, glossy paper, etc.

Masking often can be detected by the naked eye, particularly by transmitted light, and when it is practiced without erasure.

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Cases of covering which are imperceptible to the eye can usually be detected under dark ultraviolet light, as the areas covered usually emit fluorescence different from that of the surrounding portions of the paper.

Embossing and punching the letters or numerals by means of check writers offers a very good safeguard against covering over.

Masking is done mainly with water colors which dry to a dull finish. But it can also be done with oil colors. The solvent indicators (discussed later) offer a certain assurance against their use. But this protection could be circumvented because masking, can also be executed dry, for instance with foils or transfer papers.

Entering the amounts secretly protects against masking only under certain conditions.

Bleaching out handwriting by means of light (ultraviolet light has a particularly strong effect), is probably rare in the practice of forgery. Only in the very rarest of cases can it be used without leaving some easily visible trace. The detection of such traces, even if invisible to the eye, is even easier with the aid of the dark ultraviolet light. Inks usually used for important documents, especially iron gallate ink, cannot be bleached out in this manner, but this method of forgery may be practiced very successfully with aniline inks. The bleaching-out method can become particularly dangerous when the light is permitted to attack only the lines of the writing. In such a case even the best safety paper no longer offers any protection. However, it does apply when the paper contains light-sensitive substances which for example darken when exposed to light.

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The best safeguard against bleaching out of handwriting by means of light lies in the employment of light-fast inks, and in the subsequent examination of the writing in ultraviolet light. Secret indications of the maximum value, and cryptograms, also afford protection.

The punched-out script of the check writer likewise offers complete protection against these possibilities of forgery.

Of particular importance are the methods for protecting the content against forgery by chemical means. These are the processes most frequently used in forgery, as ~~they are very easily executed~~ without leaving visible traces. The patent literature contains an unusually large number of proposals for providing safeguards against chemical erasure. For these reasons these protective methods will be discussed fully below, and protective methods already discussed will be covered again because an isolated process, when seen from the point of view of overall protective technique, may be worthless, and only become useful in combination with other procedures.

The most important of the protective methods against chemical bleaching of handwriting are based on the employment of forgery indicators -- also called protective reagents -- which are used either alone or in combination with protective measures associated with the technology of paper-making, printing, or handwriting.

Forgery indicators are chemical substances which react with chemical materials used by forgers for the removal of written or printed characters. Examples are the hypochlorites, permanganate, acids, etc. More generally, however, all materials or agents which

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signal a specific attempt at forgery belong in this category. The name has been chosen in association with the familiar acid, alkali, or other indicators used in analytical chemistry. As in analytical chemistry, an indicator signals the presence of a specific substance in the material to be analyzed. Thus the forgery indicator tells whether a forger has attempted to remove writing, etc, with a specific chemical agent. Forgery indicators, which may be present either in the paper, the ink, or the printing ink, react with ink eradicators, or in general with chemical reagents employed by the forger in altering the sense of a document. They usually do this by changing or producing a color which immediately discloses any attempted forgery to the naked eye. The fact that there is such a color change in a safety paper however does not in itself prove that a forger has really been at work (because color reagents might also come in contact with the paper by accident), but at the outset it has only the value of a warning or a tip to cast suspicion on the document. Only closer examination of the paper will answer the question whether or not forgery has been committed.

The most important ink removers (see chapter on forgery) are oxidizing agents (hypochlorites, permanganates, etc); reducing agents (hydrosulphites, sulphites, stannous chloride, etc); acids (oxalic acid, acid oxalates, etc); and alkalis (caustic soda, etc). Of these the oxidizing agents are by far the most important and effective. Thus, forgery indicators (primary), must be substances which react to produce a color change with oxidizing agents, reducing agents, etc. But since these color changes can usually be made to disappear again in one way or another by adding other chemicals, it is necessary to employ further (secondary) forgery indicators which safeguard against such reversals of the primary reactions or,

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rather, indicate the reversal by another color-changing or color-producing reaction. Forgery indicators generally include all those substances which not only indicate an attempt at chemical forgery but also prevent the forger from deactivating the indicator itself. The category of forgery indicators therefore includes indicators for oxidizers, bleaches, and corrosives.

Reduction indicators which under certain conditions may also be bleach or corrosion indicators.

Alkali indicators, which produce color changes with alkalis.

Acid indicators, which react with acids to produce color changes.

Solvent indicators, which reveal the use of solvents such as those used for the removal of forgery indicators.

Cover or mask indicators, which show attempts to cover erased areas with colors.

Erasure indicators, which are sensitive to mechanical erasing.

Pressure indicators, which indicate whether the paper was subjected to high pressure after manufacture.

Heat indicators, which show whether the paper has been subjected to the effect of heat, for instance of a hot pressing iron, or a calender.

The question now is, what chemical and physical properties should a substance possess in order to make it useful as a forgery indicator. These properties may be characterized as follows.

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1. Volatility. The forgery indicator should not be volatile nor sublimate at ordinary temperatures, so that its presence in the safety paper is assured for an unlimited or practically adequate period of time.

2. It should undergo no or only practically insignificant changes under the influence of atmospheric phenomena such as light, air, carbonic acid in the air, moisture in the air, etc, so as not to give the false impression that attempts at forgery have been practiced on the safety paper. The forgery indicator must not lose its effectiveness under the influence of the atmospheric phenomena.

3. The forgery indicator must not destroy the paper or the printing inks, etc, prevent the printing ink from drying, nor exhibit other properties incompatible with the technical production of safety paper.

4. The forgery indicator must have as little odor as possible.

5. The forgery indicator must be nonpoisonous, or only slightly poisonous.

6. The more active the forgery indicator, that is, the stronger and faster the color change appears with a minimum of indicator the better it serves the purpose.

7. The color change must not be reversible or destructible by means of any chemical or physical agent. This requirement is impossible, or only partially possible to fulfill in most cases, and secondary forgery indicators must be put into action.

8. In order to prevent the forger from removing the color spot by means of mechanical erasure, the color change must penetrate as deeply as possible into the paper and not appear only on the surface.

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9. The forgery indicator must be intrinsically insoluble in all inorganic and organic solvents which do not destroy the paper or become insoluble after being combined with the paper under the influence of light, air, or chemicals. This makes it impossible for the forger to eliminate the indicator and then to proceed with his forgery.

10. The range of reactions of the forgery indicator must be as wide as possible; that is, it must react with oxidizers, reducing agents, acids, alkalis, etc. It is clear that this requirement is not simultaneously compatible with the previous one. For example, a solvent indicator as a rule cannot be insoluble.

Furthermore, the forgery indicator should not make the safety paper unduly expensive, and preferably should be difficult or impossible to obtain on the market. Thus a possible exact imitation of the same safety paper, or a repair or coloration of washed-out areas with the same forgery indicator is made more difficult. But this requirement is of little importance as in many cases such repair is either unnecessary or can be accomplished in other ways. But if the forgery indicator is impossible or difficult to get on the market or hard to get, its value as a means of authentication is increased, In the last analysis this is true of all forgery indicators to a certain degree. However, it should be remembered that the forger may produce an unknown indicator by extracting it from other blanks (checks, notes, etc) on the same paper.

In theory, a forgery indicator may have any intrinsic color. But certain colors are recommended on the basis of protection against falsification by photographic means (q.v.), especially by color separation. Most of all, however, in the sense of the

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previous requirement (see No 6, above) of the greatest possible color change, the intrinsic color of the forgery indicator should be markedly different from that of the reaction product.

Colorless forgery indicators are of particular interest. On the one hand they make it possible to produce hardly visible markings upon which a considerable number of safety printing processes are based; on the other hand they make it possible to produce white safety papers. In the case of a paper made with a colored forgery indicator, most forgers reckon from the outset with the possibility of a color change, and prepare for it. But this is less frequently the case with white safety paper which, instead, causes the forger to operate carelessly. As a result the probability with which the attempted forgery can be identified is increased. Colorless safety papers or safety printings therefore present particularly dangerous situations for the forger. As white papers are much preferred for writing purposes, white safety papers also have an enormous commercial advantage over colored papers. But from the standpoint of protective technology it must be noted that, unless the necessary precautions are taken to prevent it, a colorless forgery indicator can readily be removed from a paper without leaving a trace.

To meet this latter contingency, solvent indicators should also be employed in these cases, for instance in the overprinting. Before cashing a check one could of course determine in advance whether or not the written areas contain the forgery indicator. This could be done by means of a corrosive ink for example, but such a process would be impracticable, as the document would become illegible as a result. The process described in US patent No 1584850 (see below) is better in this respect.

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A careful forger who intends to alter characters written in ink -- to change a 1 to a 4 for example -- will not try to eradicate the entire 1, but only the diagonal stroke. Nor will he immediately apply a whole drop of the corrosive to the paper (Figure 8), but only to those strokes or points that he wishes to remove (Figure 9). This can easily be done with a fine point which he can make out of wood, glass, or some other material, or with a gold pen. In this way the repairs, if indeed repairs appear necessary, can be carried out easily -- even on many safety papers -- by recoloring, for example. This procedure, designated as single stroke bleaching (Figures 7-11), is one of the forger's best techniques. Consequently, it is obvious that a good safety paper must have special safeguards against it. Many of the processes which have been used to manufacture safety paper use a weakly sized paper for this purpose, or weaken the sizing at the same time that forgery indicators, such as oxidation indicators, are applied to the paper. But the forger can protect himself against weak sizing by applying the corrosives in the form of thick pastes made with starch paste for example, which will penetrate unsized paper only slightly; or he will first paint the weakly sized paper with a dilute gelatin solution or a similar substance, provided the safety paper is not protected against this by solvent indicators. Even in the latter case he can under certain conditions circumvent the action of the solvent indicator by the dry application of a size under pressure. (Heat indicators or pressure indicators are to be employed to prevent this.) Another principle may be used as an indicator for stroke bleaching. We shall explain it in somewhat greater detail. It is based on the principle that safety paper is made in such a way that gases or vapors develop at the points where corrosives

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are applied, causing color reactions in their immediate surroundings. The forger is then forced to treat these adjoining discolored areas with a bleaching agent, and stroke bleaching alone will not be feasible. The gases or vapors in question include chlorine, bromine, iodine, ammonia, hydrogen sulfide, and others. They may be initially present in the paper in any suitable combined form. This would be preferable. Or they may be introduced into the corrosive. (Hypochlorites for example always develop some chlorine in gaseous form). Let us assume that a safety paper contains, for instance, fluorescein and bromides (or iodides). If a drop of an acid oxidizing agent such as acid permanganate or chromic acid is applied to such a paper, bromine or iodine will develop and react with the yellowish fluorescein in the vicinity of the liquid, forming deep red bromine or iodine eosin. Chlorine of course liberates the bromine or iodine from bromides or iodides. Alkaline hypochlorite solutions, too, are able to cause this reaction, if less strongly than acid solutions. Thus, if a hypochlorite is applied to a safety paper containing bromide or iodide, bromine or iodine will be formed which, depending on the composition of the safety paper will react with the fluorescein in the vicinity of the drop of liquid that has been applied. Iodine alone will begin to color the cellulose fibers around it. Hydrogen sulfide, too, can be employed as a stroke bleach indicator in a similar manner. It also can be made to react with acids and alkalis, and not only with oxidizing agents.

The principle of "Inkset" safety paper, (to be discussed later) if properly used, provides a safeguard against stroke bleaching. It is usually a reaction between ink and paper.

The fact that the addition of detergents to the ink or paper under certain conditions may likewise increase the protection against chemical eradication has already been mentioned.

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Although most of the currently known forgery indicators do not identify every possible content forgery with absolute certainty, a good combination of different indicators goes a long way toward that goal. Combining too many indicators is not advisable since one and the same area of a document, usually will not withstand the successive applications of many corrosives, acids, etc.

Forgery indicators come from the realms of both inorganic and organic chemistry. From the standpoint of protective technology there is no theoretical difference between forgery indicators of either group, and there are many processes in which both inorganic and organic forgery indicators are used together. Under certain conditions this could lead to advantages not only for protective technology but also other advantages such as increased light-fastness or increased stability in the presence of air. Thus, the stability with regard to light of benzidine and other organic amines, indophenols, and the like, is definitely improved by manganese sulfate and other inorganic sulfates.

In the following, the presently known forgery indicators according to the patent literature will be listed and their chemical properties indicated insofar as they are important for protective technology. At the same time, related or associated material is presented. A critical discussion of the individual processes will be presented as well as some technically useful hints or indications of further chemical possibilities.

The importance of the correct choice and combination of forgery indicators cannot be emphasized strongly enough. A paper insufficiently "protected" against content forgery, which Bausch calls "pseudo-safety paper," can be more dangerous than an ordinary

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paper without safety indicators because banks, the police, etc are lulled into a false sense of security while the practiced forger finds practically no obstacles in his way (W. f. P. 1934, page 208).

The oldest forgery indicators are the dyes. Most inorganic and organic dyes can be used as indicators in one way or another. Only a few examples will be given here. Among the inorganic dyes, Prussian blue, or Milori blue reacts in the presence of alkali. Its combustion residue is a brown ash.

Ultramarine, which reacts with chlorine and acids, leaves a blue ash. Acids discolor it, and it develops the characteristic odor of hydrogen sulfides.

Ultramarine green
Ultramarine violet — react like ultramarine blue.

Lithopone is likewise sensitive to acids and when brought in contact with them emits the typical hydrogen sulfide odor.

Most of the organic dyes, especially the so-called coal tar dyes, are sensitive to oxidizing agents; many of them also to reducing agents, acids, and alkalis. The details cannot be dealt with here, especially as the manufacturers in their specifications have published the properties of their dyes, including their reactions to oxidizers, solubility, etc (see also Schulz, Farbstofftabellen [Dyestuff Specifications], and the Color Index).

It is to be noted here that the ordinary indicators used in analytical chemistry have been variously suggested and also used as forgery indicators. They include phenolphtalein, methyl orange, etc. For instance, the postage stamps of the German Reich before World War I were coated with phenolphtalein as a mark of authenticity.

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As forgery indicators they are in themselves generally unusable, but occasionally are quite serviceable in combination with other forgery indicators.

The earlier safety papers were produced with the aid of dyestuffs, and the processes for making them originated in about the 1860's. Dyestuffs still form the basis of most of the safety papers available on the market today. But they are often most ineffective and the protection they provide against forgery is either very slight or altogether illusory.

According to German patent No 32403, (Patentpapierfabrik at Penig, Saxony), paper pulp or finished paper is treated on one side with ferric salts and with ferrocyanides -- lead ferrocyanide or the like -- which are soluble in acids but not in water; on the other, with iron oxide saccharate and water-soluble ferrocyanides. Thereupon they are redyed with indigo or acid fuchsin. Any attempts to alter the writing on this type of paper, regardless of the chemical means used, is supposed to be noticeable immediately.

The pulp may be slightly mordanted with ferric acetate [essigsaures Eisen] and mixed in the beater with a quantity of freshly precipitated lead ferrocyanide sufficient to produce the desired coloration of the safety paper when acted upon by acids. If the paper pulp is acid, as is usually the case with papers having a resinous sizing, then some blueing will take place, as Prussian blue is formed. This must be kept light, so the acid must be neutralized with alkalis. But if no blueing takes place, potassium ferrocyanide must be added. The light blue color may be reinforced with indigo blue, which likewise reacts with hypochlorites, or it may be given a reddish shade with acid fuchsin. Such a paper turns deeper blue when acted upon by strong acids. With weak acids it does not react at all.

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According to German patent No 32453 (Patentpapierfabrik at Penig), the paper pulp is dyed with indigo -- optimally vatted blue -- and mixed with a chromate (barium chromate) which is soluble in acids. The proportion of the latter governs the shading of the paper as desired, from blue-greens to yellow-greens. On such paper dilute mineral acids liberate chromic acid, which destroys the indigo blue. Chlorine and chloride of lime solutions likewise destroy the indigo blue, and a yellow is produced.

Such a safety paper today no longer offers sufficient protection against forgery with chemical eradicators. Furthermore, the color can rather easily be removed from the paper -- the barium chromate with a neutral solution of sodium sulphate, or the indigo with soldium hyposulfite for instance. Next the paper can be redyed the desired shade. Individual strokes of the ink writing, too, could be eradicated and the areas covered over with water colors of the proper shade, and the forgery would be difficult to notice by a layman.

To render such tampering with the paper more difficult, and at the same time provide a safeguard against mechanical and chemical erasure is the object of the 3-layer paper produced under US patent No 1910568 by T. J. Snyder, of Chicago. The top and bottom layers of the paper consist of tissue paper. The outside face of each of the outer layers is dyed with a sensitive dye. The middle layer of paper is similar in composition to the so-called Bible paper, which easily absorbs ink.

When this 3-layer paper is written on in ink, the ink penetrates the outer, tissue-paper, layer and enters the middle layer

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made of Bible paper. Any attempt at mechanical erasure is easily noticeable. If acids or ink bleaches are applied to the paper, the dye on the outside surface will react with it and form a colorless spot. Furthermore, the tissue paper layer, will wrinkle and separate from the middle layer, whereupon the traces of the original ink that have penetrated to the middle layer will become visible. If an attempt is made to bleach out the latter with corrosives, the middle layer will be destroyed.

The different layers of paper can also be of different colors, of course.

Thus, the safety paper is protected against forgery in a certain limited measure. It is protected not only chemically but also by the application of paper technology against forgery with chemical corrosives and water color solvents. But aqueous solutions are not the only ones suitable for chemical eradication and redyeing, even though they are the most widely used in practice, and even so such paper offers little protection.

A safety paper can be produced according to a process developed by the author, which indicates any attempt to eliminate forgery indicators. That is to say it consists of a solvent indicator which is prepared by covering a paper stock with a layer which contains a dye which is suspended in solid form in a bonding agent. The dye is easily soluble in water, possibly fast to chlorine, and may have other properties. The bonding agent is thermoplastic, so that a very thin, unsized paper impregnated with the forgery indicator can be made to adhere to the color layer when dry (Figures 12 and 13). This safety paper not only reacts to any tampering with solvents but also to any wet chemical erasure.

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In the latter case the spots become darker (Figure 13). Instead of dyestuffs colorless substances which produce colors in the presence of moisture may be incorporated in the middle layer. The paper can also serve as an Inkset safety paper.

By no means all forgery indicators are attacked by all agents which remove ink. A few processes therefore are based upon the use of ink dyes as forgery indicators. However, their effectiveness usually presupposes that the paper is to be inscribed with ink identical to that used in the forgery indicator. Thus the forger's correction of bleached areas is facilitated and such forgery indicators must be incorporated in the paper in special ways in order to interfere with corrections. In the process protected by German patent No 422374 (R. E. Liesegang, of Frankfort on the Main) paper fibers are colored with ink, or the color is produced upon them by means of the usual chemical reactions. These fibers are sprayed onto the paper web while it is still on the wire mesh, or before. The fibers are intimately united with the paper by the pressure of the drying cylinders, and a mixed paper is produced which will always react to ink removers like hypochlorites, oxalic acid, etc. However, it is easy to restore a chemical or mechanical erasure on such paper, quite apart from the fact that it is not protected against individual stroke bleaching.

Another method of combining ink and paper is suggested by doctor Emil Haussmann, of Berlin in German patent No 303989. The dyed pulp is couched together with 2 covering layers which are dyed slightly or not at all, so that the finished paper is in 3-layers. If, for example, the paper is to be written upon with iron gallate ink, the paper pulp is dyed with tannin and ferric salts.

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The top layer serves as the writing surface and most be as thin as possible and slightly absorptive, so that the writing will penetrate into the middle layer, which in turn is likewise slightly absorptive so that it may easily absorb any possible ink bleach. The lowest layer serves as backing and is either identical with the top layer or it can also be dyed or imprinted.

If mechanical erasure is attempted, the colored middle layer is exposed or shows through more strongly. A practiced forger, of course, will then attempt to correct the error by coloring it with a crayon or the like, or by bleaching the middle layer and, if necessary, redyeing it to the desired extent. But usually the forger would not even consider mechanical erasure, but would resort to chemical eradicators. In this case careless work would likewise destroy the color of the middle layer, so that a light spot would become visible, especially if the paper is held against the light. The forger will not be able to restore the color of the middle layer because it is covered on one or both sides with a colorless layer or one of a different color. But if he tries to balance the light spot by applying color to the upper or lower layer, it must be colored so heavily that it becomes readily apparent, especially when the paper is held up to the light. And if it is colored so lightly that the correction is not apparent in reflected light, it will be too light in transmitted light. As previously mentioned, however, the error can be largely corrected by coloring over it with a crayon or the like. Safety paper made in this way is particularly vulnerable to individual stroke bleaching by means of bleaches in paste form.

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US patent No 1938543 (J. C. Sanburn, Strathmore Paper Company, West Springfield, Massachusetts), aims at safeguarding against counterfeiting and content forgery by using the methods of paper technology. The paper is produced either with a certain quantity of detecting fibers of a special color and with other fibers having the same coloration, so that the 2 kinds of fibers cannot be distinguished from one another by the naked eye, but can be distinguished when a reagent is applied. Or the fibers are pretreated with a chemical reagent and then made into paper with other fibers, the detecting fibers again being of the same color as that of the finished paper.

The main object of this process is to develop:

a. an indicator of attempted or completed chemical eradication, which discolors the detecting fibers;

b. a safeguard against counterfeits, which, like a chemical preventive of counterfeits, makes the detecting fibers visible with certain reagents, thus making it possible to determine the authenticity of the paper.

In yellow paper, for instance, the detecting fibers are dyed with brilliant Paper Yellow, a dye sensitive to alkali. If the finished paper were to be treated with an alkali such as ammonia in liquid or gaseous state the detecting fibers would assume a reddish color. Also, the color of the detecting fibers may be different from that of the others. Other coloring agents used are Congo red and sodium diphenyldiazobinaphthionate, which turn blue with acetic and stronger acids.

Insofar as Congo red is concerned, its suitability for the manufacture of safety papers is questionable, as it is known that

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it will turn color even under the influence of the sulfuric acid present in the atmosphere in industrial sections.

Such a safety paper is better protected against stroke bleaching than those mentioned previously; and the correction of erasures is also somewhat more difficult.

It is not always easy to dye fibers identically and to give them the desired properties. It would be better to color the fibers with different colorless forgery indicators, which develop different colors with ink bleaches, and incorporate them into the paper. Then there would be at least a certain element of counterfeit prevention in the paper. Its value as a forgery preventive would likewise be enhanced, insofar as a characteristic granite-paper effect would result if corrosives were unlike what may happen if the coloration is uniform, this effect is not so likely to raise the question of whether the paper was soiled accidentally, for example by a drop of ink.

Chemical forgery-proof safety papers made with dyestuffs generally show a lightening or fading of the color in the erased area when chemical erasure is attempted. Because the writing must be easily readable, the coloration may not be strong or dark. Therefore in all these papers erasures are not very noticeable and can more or less easily be corrected by coloring over them, for example -- much more easily than could a dark colored area. Recently, therefore, forgery indicators have has been eagerly sought which are intrinsically colorless or light colored but produce the darkest possible coloration with chemical erasing agents. Here the erasure is much more noticeable and can be satisfactorily covered only with great difficulty; and a forger is not notifiod in advance of the

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fact that he is dealing with a safety paper. The hitherto patented or usable forgery indicators and safety processes using paper technology of this type are noted below.

According to British patent No 159740 (1920) (Waterlow and Sons Ltd. and E. Goodmann, Finsbury), a black or dark colored but fast-dyed paper is coated on one or both sides with an opaque, light colored wash, for instance with manganese ferrocyanide, which conceals the black color of the paper base. The manganese ferrocyanide is destroyed by ink etching agents (ink eradicators) and the black undercoat appears on the areas to which eradicator is applied. Mechanical erasure also is impossible without the appearance of the black foundation. But it should not prove too difficult to recover the black color with water color, or dry, for instance with embossing paper. Likewise, the change which the manganese ferrocyanide undergoes under the influence of oxidation agents can be reversed with bisulphite. All or most of the forgery indicators of course are applied to the paper in this manner -- as surface colors -- and unless they are eliminated by counterfeit-proof printing or other safety measures, they all have the above-mentioned shortcomings to some extent. In general it is more advantageous to saturate the paper completely with the forgery indicator (which can be done in the beater or by subsequent treatment), and to use a weak size, so that the spot produced by a chemical ink eradicator soaks as deeply into the paper as possible.

The protection provided by the process in German patent No 546627 (see page 65), also rests in part on this necessary penetration of the eradicator into the paper stock. (Absorbent, coated paper.)

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If a forger wishes to remove a portion of the script from such a safety paper by means of a chemical ink eradicator, the latter will also soak into the underlying layer, where it is permanently noticeable. If the script on the upper surface of the document is eliminated with a weak chemical reagent, and a new script substituted therefor, the original script will be slightly visible (perhaps in dark ultraviolet light) on the reverse side, so that the alteration will be detected. Strong chemicals will soak into the mass of the middle layer and, precisely because of its absorbency, will be difficult to remove. Then, too, discoloration, etc, makes it immediately obvious that an attempt at forgery has been made. An erasure of the script would scarcely be possible without destruction of the covering layer, and even if a new layer were applied, the body of the underlying layer would reveal this alteration.

A safety paper which develops a dark, indelible color with ink eradicators by means of inorganic, almost colorless forgery indicators, is manufactured by J. Genoese, San Francisco, under US patent No 1026078. The paper is first impregnated with one substance and then coated with a different kind of solution, both of them reacting with ink eradicators. The impregnating solution causes spots resulting from ink eradicators to soak through the paper so that they are not easily removable. It is composed of water, alcohol, lead carbonate, zinc sulfide, and soldium bromide. The paper is dipped in this solution -- or, rather, suspension. The lead carbonate and zinc sulfide are supposed to prevent the ink from running. Sodium bromide gives a yellow spot reaction to ink eradicators, but not with all of them! The dry paper is then coated -- or, rather, imprinted -- with a solution which has the properties of a printing ink. It is composed of glycerine, glucose

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(to effect adherence to the paper), zinc sulfate, magnesia (to produce a printable consistency), iodine (which is supposed to produce a blue color with the ink corrosives), nickel chloride (which produces a green color with alkaline corrosives), and alcohol. The zinc sulfate is added for the purpose of further darkening the spot formed in reaction to corrosives. Iodine and nickel chloride are not absolutely necessary. Probably the iodine sublimates off of the paper in a short time or, if it is not in chemical combination, becomes noticeable because of its unpleasant odor.

Most of these forgery indicators can be eliminated from the paper before forgery, if no solvent indicators are present. Lead carbonate and zinc sulfite are insoluble in water, to be sure, but the black zinc sulfide formed therefrom with acids is easily oxidized to white lead sulfate by means of hypochlorites.

According to US patent No 1804978, in the name of the same inventor, the paper is treated with a solution composed approximately of the following substances.

141.75 g	alcohol
1892.6 g	water
7.05 g	iodine
7.05 g	cobalt nitrate
3.544 g	sodium thiosulfate

The solution is colorless, therefore all the iodine is combined.

Such a safety paper offers an intrinsically quite inadequate safeguard if it is not combined with other forgery indicators, especially with solvent indicators. For cobalt nitrate and thiosulfate, or their exchange products with iodine, are easily washed out of the paper with water before a forgery operation, whereupon the forgery can be perpetrated as upon ordinary paper without forgery-proofing.

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Furthermore, the spot formed with iodine is easily bleached, for instance with thiosulfate or with alcohol. The black coloration which cobalt produces with alkalies (formation of cobalt hydroxide) is likewise easily removed, for instance with acids.

The forgery indicators which produce colors in reaction with the ordinary writing inks, and thus to a certain extent fix them (inkset), or supposedly make them unbleachable, are partly inorganic and partly of an organic nature. Most of them also react with ink bleaches.

One of the oldest processes of this kind is that of Ballandes of Paris (see Andes, Papierspezialitaeten [Special Papers], page 77) in which calomel is added to the paper, either in the beater or as a coating. To write on such a paper one needs to use a special writing ink made of gum-water, alum, and sodium sulfite. Due to the action of sodium bisulfite a black script is produced, which would fade however if the alum were not present. The alum is supposed to fix the black script upon the paper.

Calomel, or mercurous chloride, is of course rather poisonous. It becomes yellow on exposure to light and also as a result of heat or friction. Alkaline hydroxide reacts with it to give black mercurous oxide; ammonia gives black amino-mercurous chloride. Despite these most interesting safety properties it is not to be recommended because of its poisonous nature and its high price. Furthermore, the black colorations readily dissolve in nitric acid.

The process in US patent No 1217076 (E. E. Schmidt, Covington), is also based upon the Inkset, principle -- the reaction between the ink and a substance contained in the paper. Here script with

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a ferrous ink, specifically with iron gallate ink, is not supposed to be eradicable either by chemical or mechanical means. The following solution is said to be particularly suitable for the treatment of the paper:

907 g ferrocyanide of sodium or potassium

85 g ox gall

28.4 g magnesium sulfate

in 15 l of water.

Ferrous inks react with such a paper, or with the ferrocyanide salts, to form Prussian blue, which is stable to dilute acids, but with alkalis forms the brown-yellow iron hydroxide. Removal of the script with ink eradicators is thereby rendered more difficult, but, contrary to the assertion of the patent, is still possible, and actually in rather simple fashion. To be sure, the paper is more or less affected, depending on its composition.

In the foregoing formula, the ox gall serves to reduce the surface tension of the solution, in order that it may penetrate into the paper more easily. It also stimulates the penetration of the ink into the paper (as ox gall acts as a desizer), which makes mechanical erasure also more difficult. The magnesium sulfate prevents the ink from running i.e., drying with indistinct edges. This effect is probably based on a sort of salting out.

Dyestuffs may be added to the above-mentioned solution as forgery indicators to provide further protection against chemical and mechanical erasure. If the dyestuff remains only on the surface of the paper, not only the chemical but also mechanical erasure is made more difficult. The patent furthermore claims that if,

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after mechanical erasure, it is attempted to restore the original color by coloring over with some coloring agent, the chemicals contained in the paper will prevent the restoration of the desired shade.

The same inventor (E. E. Schmidt, Paramount Safety Paper Company, Chicago) describes a further development of the preceding process designed for imprinting paper, whereby the solution is given a printable consistence by means of a thickener (US patent No 1269863).

For example:

284.0	g	sodium or potassium ferrocyanide
340.0	g	sodium or potassium iodide
28.5	g	glycerine
28.5	g	ox gall
453.0	g	sizing

are mixed with sufficient water to yield 3.8 l.

The sizing is composed of:

22.7 kg tapioca starch

1.6 kg caustic soda

159. kg water

boiled together for approximately one hour. The caustic soda serves to dissolve the starch and is effectively neutralized by means of hydrochloric acid.

The above solution may be applied to the paper as a coating or imprinted thereon in fine lines as in the engraving processes.

The effect of the chemicals is the same as that in the previously described patent, except that the effect of the iodides is added.

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The latter, when added to acid eradicators or treated with an acid-alkali combination -- which is particularly effective in ink eradication -- form the iodine which turns the yellowish cellulose fibers blue. This iodine coloration is of course very volatile because of the instability of the iodine. The iodine can also operate as a highly energetic chlorine carrier, if hypochlorites are used for bleaching and chlorine forgery indicators are present.

It should be mentioned that unless other safety features have been incorporated as well -- especially solvent indicators to prevent elimination -- such safety paper can easily be deprived of its forgery-proofing properties by first eliminating those substances which are highly soluble in water.

US patent No 1900967 (F. S. Wood, Quincy, US) states that the paper produced with potassium ferrocyanide according to above-mentioned patent No 1217076 fades and that this is can be avoided by making the paper containing potassium ferrocyanide moderately alkaline. The necessary alkalinity can be produced by means of carbonates, especially alkali carbonates.

In this connection, French patent No 769012 (A. Mache) must be noted. Under this patent an ink-set safety paper is produced by combining the paper pulp with potassium ferrocyanide and buffers like disodium phosphate or mono potassium phosphate. These substances can also be added to the size used for the surface sizing.

US patent No 1951076 (F. S. Wood, of Quincy; Inkset Safety Paper Company, Boston), states that it was previously impossible to treat finished sulfite-cellulose paper with such substances as a potassium iodide carbonate solution. Because of the loss of

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pulp and the high price of the chemicals it was also much too expensive to treat the pulp with such substances in the beater prior to manufacture -- to say nothing of possible damage to the bronze in the beater vat, the wire mesh, or other machinery parts.

Therefore the above-mentioned patent proposes, as an innovation, to treat sulfite cellulose paper with a solution composed of water, decolorized alkaline tincture of iodine, glacial acetic acid, and tannin, the latter 2 neutralizing the alkali.

The decolorized iodine tincture and tannin give the paper a dark color when it is treated with an ink eradicator. The tannin serves primarily to make the coloration appear also in the interior and on the reverse side of the paper. The glacial acetic acid serves to neutralize the alkaline iodine solution and prevents subsequent discoloration of the paper.

As it is often desired to establish not only that an attempt at forgery has been made but also which numerals or letters the forger tried to remove, the inventor has also given this paper the so-called Inkset property, which is a fixation of the ink script. This property is said to be based primarily on the relationship of the tannin to the glacial acetic acid. The latter makes bleach solutions soak into the paper, sometimes all the way through to the reverse side.

Safety papers made in this way form iodine with most oxidation agents, such as chloride of lime and other hypochlorites. But any discolorations that are caused in this manner can be removed with the greatest of ease by applying sodium thiosulphate for example. The case is different when still another substance is present to

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react with iodine to produce a coloration. Such a substance is fluorescein, which, when combined with iodine (or iodine chloride) and alkali forms the red dyestuff erythrosin G. The latter, unfortunately, is decolorized again because of an excess of chloride of lime.

The high solubility of the alkaline iodides and of the tannin would suggest the utilization of a solvent indicator. In any case, the tannin is rather strongly adsorbed by the fibers of the paper.

US patent No 1939378 by the same inventor, concerns a method of producing safety paper of the kind just described as cheaply as possible, for example by making it at the time the paper stock itself is made. The paper is superdried on the paper-making machine, so that it contains no or very little moisture. Hereupon nozzles apply a precisely regulated spray made up of a solution of decolorized iodine to which tannin and acetic acid have been added, or some other forgery indicator, so that the paper takes up approximately 8% of water and no further drying or impregnation process is necessary. The patent asserts that by applying this process to a sulfite the price is increased 3 1/2 times with an increase of only about 10% in the cost of production.

US patent No 1864116, which will be discussed later, is also based on the Inkset principle and uses tannin.

The process of German patent No 259850 (R. C. Menzies and J. E. Aitken, Musselburgh, Scotland) is likewise based on the Inkset principle, and ink is said to be absolutely impossible to remove from it -- a quite dubious claim.

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In this invention a soluble thiocyanate, preferably ammonium sulfocyanate combined with a soluble lead salt is added to the paper pulp or to the finished or semifinished paper. For maximum effectiveness the resulting lead sulfocyanate should make up 5 to 20% of the weight of the paper ! The lead sulfocyanate can also be added directly to the beater vat.

As most inks are acidic -- at least those composed of tannin or logwood, but often the aniline dyes as well -- it is possible to produce a paper which will undergo a color reaction with the acids in the ink. In the present case, the lead sulfocyanate is attacked by the acids in the ink, being transformed on the one hand into black lead sulfide, while on the other hand the remainder of the sulfocyanate is changed to iron sulfocyanate in combination with the iron in the ink. Thus a sort of fixation of the ink is achieved. The lead sulfide is barely soluble in weak acid solutions and therefore cannot be removed from the paper with acids. But it is possible to oxidize it to white lead sulfate on the paper by means of concentrated nitric acid or hypochlorites, or to transform it into lead sulfate with sulfuric acid. Other objections to the process mentioned are the extremely poisonous nature of the lead combinations, particularly lead sulfocyanate, which is fairly soluble in hot water. Used by itself, the process can give only slight protection, at best, against chemical erasure, and none against mechanical erasure.

As for the iron sulfocyanate formed when iron gallate ink is used, it is decolorized by light, phosphoric acid, and many organic acids (oxalic, tartaric, lactic, citric, and others). It is a much too unstable substance.

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(Among the heavy metal sulfocyanates there is the white-colored sulfocyanate of mercury, which forms the familiar Pharaoh serpents when heated. This property could also be used to indicate authenticity. But sulfocyanate of mercury is likewise very poisonous.)

There are numerous other possible methods of producing Inkset safety papers. These processes often depend on writing with a special kind of ink, and are therefore less desirable, even though they might offer great advantages in technical security.

The Inkset safety papers in general have the advantage that the forger is forced to leave the corrosive chemicals in contact with the ink for a longer time, so that a deep penetration into the paper and a thorough reaction with forgery indicators is produced. But the same result can be achieved with good forgery indicators.

Among the organic forgery indicators, a leading role is played by certain aromatic amino and hydroxy combinations and by aromatic aminooxy combinations, either by themselves or in combination with other forgery indicators.

One of the oldest forgery indicators is aniline, or aminobenzol, whose mineral acid salts combine with many oxidizing agents, particularly in the presence of catalysts (vanadium salts), to form aniline black. This is hardly removable from the paper. The so-called laundry inks, used for marking laundry and required to resist chlorine bleaches, also have an aniline base.

These mineral acid salts of aniline are of course widely used in the production of chlorine-fast black textile dyes by means of oxidation (Rettig, Bull. Soc. Ind., 1836, Mulhouse, page 179). It has been found that a large number of aromatic amino

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and aminooxy combinations can easily be oxidized to form sometimes highly fast colored products. In dye chemistry these are called oxidation colors. The most important combinations, which sometimes yield deep colors practically indestructible by hypochlorites, manganese hydroxide, and other oxidizers, are o- and m-toluidine, o-, m-, and p-amidophenol, p-amidodiphenylamine, and p-oxy-p-amido-diphenylamine. Also the commercial Ursols or Furreins (m-diamidoanisol, 44' diamidodiphenylamine, 1-5 dioxynaphtalin, and others). Some of these products -- like aniline -- are almost useless as forgery indicators because of their low stability; others are protected by patents. Several leuco-indophenoles and leuco-indamines, patented in the United States as forgery indicators by W. N. Doushkess (US patents Nos 1866400 and 1916606), belong to this class.

The leuco-indamines and leuco-indophenoles yield strong color changes when treated with ink eradicators. As we have already mentioned, aromatic amines and the like, which have been suggested for this purpose, usually suffer from a lack of stability to air and light. Therefore it is preferable to oxidize them into the indophenol or indamine, and then use the resulting leuco-bases, which are more stable. It has been discovered furthermore that the stability of the safety papers produced with these substances -- for example benzidine -- can be further increased by the addition of metal sulfates, so that in storage the action of light and air is substantially retarded while the sensitivity to bleaches is unchanged. Manganese sulfate is said to keep especially well and, as is known, reacts with alkaline bleaches as well. Like benzidine, manganese sulfate also partially precipitates out forgery indicators. The addition of manganese sulfate has the advantage of making safety papers extremely sensitive to alkali, in that the manganese hydroxide formed also causes a color reaction.

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It is best first to saturate the paper with a 10% solution of the leuco-compounds and not to apply the manganese sulfate (5 lbs in 100 l of water) until later. The same combinations can also be used in printing are used as in the printing of invisible marks. Chemical compounds can also be introduced into the paper stock which are later changed into indophenoles or indamines by means of appropriate reagents. These compounds, too, are protected against atmospheric influences by means of manganese sulfate.

Sulfoacids and their salts are among the countless derivatives of the aromatic amino and oxy combinations which have been suggested for use as forgery indicators.

The parasulfoacid of aniline, sulfanilic acid, is used as a forgery indicator by A. J. Cone of New York, in US patent No 1584850, specifically in the form of the insoluble mercury sulfanilate, preferably added to the pulp in the beater. It is not easily removed from the paper, thus it cannot be neutralized in advance. It is said to be more stable and light-fast than most of the other mercury salts. With alkalies it turns brown to black, while if thiosulphates (hyposulphites), sulphites, bisulphites, or ammonia are added, a brownish color results. With iodides there is a color transformation from yellow to black, while with chlorine or hypochlorites a red-brown color appears.

Although mercuric sulfanilate alone provides considerable forgery proofing, this can still be effectively improved by the simultaneous use of other forgery indicators such as sulfanilic acids or their other salts (which are applied to the finished paper stock on account of their solubility in water), with or without the benzidine sulfate (added in the beater), which is insoluble

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in water and other solvents. Sulfanilic acids and their soluble salts produce a yellow coloration in damp, unbleached, or partially bleached lignocellulose paper. If a cautious forger has washed the soluble sulfanilic acids or their salts out of a safety paper, this can be detected because a damp sheet of lignose paper, pressed against it, will not turn yellow. Thus the sulfanilic acid serves as an indirect solvent indicator.

According to the patent, a satisfactory safety paper produced in accordance with it should contain:

2% Mercuric sulfanilate

1% Sulfanilic acid or its salts (optional), and

1/2% Benzidine sulfate.

The mercuric sulfanilate combines the properties of an oxidation, reduction, alkali, and iodide indicator.

Many of the technically important sulfoacids among the amino and oxy compounds of naphthalene produce colored products in reaction with hypochlorites, but these usually disappear again with an excess of the oxidizing agent. A few of these compounds ought to be usable as forgery indicators, however.

Since Crane and Company, Dalton, US, suggested the use of benzidine in the manufacture of safety paper in English patent No 209919, this product has been widely recommended in the technical literature as an oxidation indicator. Imprinted on the surface of the paper, it can also serve -- as can all colorless forgery indicators -- in the detection not only of chemical but also of mechanical erasures. If properly printed, the areas treated are not easily identifiable and are scraped away if erasure is attempted.

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This supposes of course that the erasing is done in the usual way and not on the strokes of the writing alone. Amines of the benzidine group usually refer to benzidine and its homologues or substitution products. The salts of these substances may also be used. The most suitable are the insoluble salts of benzidine, particularly benzidine sulfate.

These substances may be incorporated into the paper stock at any stage of the manufacturing process, or applied to the finished paper, which again facilitates the detection of surface erasures. They can also be dusted onto the paper or applied with a stick similar to a lipstick, which contains the corrosive-indicators as its active ingredient.

When the pulp in the beater is being treated with the indicators, the proper proportion is 5 parts benzidine sulfate to 100 parts of the pulp by weight.

The patent states further that benzidine and similar compounds turn brown when treated with the usual ink eradicators -- especially oxidizers -- which cannot be removed with acids, alkalis, reducing agents, or other chemicals.

But the colorations of benzidine when treated with hypochlorites (a blue diphenoquinonedichlordiimine is formed) and other oxidizers are easily removable, with sodium bisulfite. US patent No 1584850 prevents this by using a reducer-indicator such as mercuric sulfanilate.

It has been shown that benzidine and its homologues, as well as its soluble salts, turn brown when exposed to light and air. The insoluble benzidine sulfate is therefore preferred because it is essentially more stable.

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It is also noted that benzidine gives a brown-red color with lignocellulose or wood chips, which is not surprising when we recall the familiar test for wood chips by means of aniline sulfate.

Regarding the stability of benzidine to light the following is also to be noted:

Benzidine produces extremely light-sensitive compounds when combined with various acid coal tar substances. In fact, the Badische Anilinund Sodafabrik (now I. G. Farben) has based a photographic copying process on this property, which is described in German patent No 337173. The addition of oxidizers, especially manganese, sodium, and magnesium nitrates, further increases the light sensitivity.

J. M. Eder, Sitzungsber. Akad. Wissensch., [Minutes of the Academy of Science], Class of Mathematical and Natural Sciences, Part IIa, Vol 130, 1922, Vienna, page 319, describes such compounds in greater detail and has found for example that a paper stock made with quinoline yellow and benzidine is approximately 1/5 as sensitive to daylight as normal silver chloride paper. Measured on the same paper stock, the relative ratings of eosin and benzidine are both 1/10.

Benzidine with cyananthrole gives black to black-violet colors on exposure to light, which go over to brown with sodium hypochlorite. Eosin A (salt-free) with benzidine upon exposure to light gives purple-red; Neptune Green SGX gives lively greens which turn dark green with sodium hypochlorite. The light sensitivity of quinoline yellow or eosin with benzidine is especially strong in the green to yellow range.

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These compounds of benzidine with acid dyestuffs would still be useable as ink pigments for printing check forms, or as paper dyes, despite their sensitivity to light, because they react to oxidizers. But they cannot be used for colorless, forgery-indicating safety papers. The foregoing details are evidence particularly for the fact that benzidine, used in certain combinations, has a particularly high light sensitivity, which must be carefully considered in the manufacture of safety papers containing benzidine.

US patent No 1627254 (B. W. Smith, Todd Company, Inc., Rochester) protects forgery indicators whose molecular structure is characterized by the fact that a group of carbon rings is interconnected in such a way that a carbon atom belonging to one of the groups of rings is linked directly to one belonging to another group, and that several hydrogen atoms of the groups are replaced by amino groups insofar as they react with ink removers to form colors.

Alpha-naphthidine is cited as an example, i.e., the 4-4'-bi-1-naphtylamine which has a formula similar to that of benzidine, except that the benzol radicals of the benzidine are replaced by naphthol radicals. This alpha-naphthidine, with oxidizers like sodium hypochlorite, gives dense, insoluble, red to purple substances. The isomers of naphthidines, particularly dinaphthylines or binaphtylines, while they likewise produce the color reaction, are less suitable because their salts are soluble. (W. M. Cumming and Howie, J. Royal Technical Coll., 3, 1933, Glasgow, 26-35, have recently conducted investigations of these substances.) It is better to use salts such as the sulfate and the chloride, as they are more stable to light and humidity, and their reaction products keep better on the paper.

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The naphthidine is colorless and reacts with bichromate, permanganate, hypochlorites, and other oxidizers to form deep-colored products which are relatively difficult to dissolve. The latter cannot be decolorized again by means of the usual reducing agents. Thus we are dealing with an irreversible indicator of oxidation. Besides, it is extremely powerful, and the addition of 15 kg to a ton of paper is said to suffice.

Alpha-naphthol [Alphanaphtidin] is produced by the oxidation of alpha-naphthylamine with ferric oxide, according to F. Reverdin and C. de la Harpe (Chem. Zeit [Chemical News], 16, 1687).

Anthracene rings may take the place of the naphthidine rings.

US patent No 1839995, by A. E. Remick (The Todd Company, Inc., Rochester, N. Y.), covers guanidine derivatives, e.g., diphenyl guanidine, triphenyl guanidine, and their substitution products, like ortho or para-ditolyl guanidine, and ortho or para-anisyl guanidine, as well as their analogues, homologues, or derivatives, as forgery indicators. These substances, which possess the properties of diphenyl guanidine, will be simply referred to as guanidine substances in the following. They are fast and colorless, react with oxidizers like sodium hypochlorites by forming insoluble, deep dark brown, easily visible reaction products which do not disappear with an excess of the bleaching agent. They are stable to light and air and are preferably used in the form of the soluble salts, such as the acetates. The paper can be impregnated with a 3% aqueous solution of diphenyl guanidine acetate and then dried. When added to the pulp in the beater, 30 lbs of diphenyl guanidine acetate per ton of pulp suffice.

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Diphenyl guanidine is of course one of the most important accelerators in vulcanizing rubber, and thus an important commercial product.

A few aromatic hydroxy compounds which can be used as forgery indicators have already been mentioned in the foregoing. A further combination of this kind is covered by US patent No 1662509 (W. R. Orndorff, Todd Company, Inc., Rochester N. Y.) -- the 1-3 dimethyl ether of pyrogallol (pyrogallic acid) and derivatives with similar reactions. These are excellent oxidation indicators. These substances and their salts are technically easy to produce, and in addition are found in beechwood creosote.

Pyrogallol dimethyl ether is a colorless substance stable in light and air. It is 1.4% soluble in cold water and much more so in hot. It is also highly soluble in alcohol, oils, and other solvents. The long-known formation of cedriret or coerulignon from pyrogallol dimethyl ether is applied to forgery-proofing in the patent cited. The pyrogallol dimethyl ether reacts with all possible oxidizers, such as chromic acid, chlorine, bromine, nitric acid, ferric chloride, potassium ferricyanide and others, almost quantitatively, by way of diphenol, into the corresponding dark blue colored diphenoquinone -- the coerulignon or cedriret (see A. W. Hofmann, Vol 11, 1878, page 329, Liebermann Ann. [Liebermann Annual], No 169, 1873, page 221). Of these substances, tetramethoxy-diphenoquinone is insoluble in most solvents but soluble in phenol. Alkalis destroy the substance in the presence of heat, while reducing agents cause the above-mentioned diphenol intermediate product to reform.

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According to the patent, addition of a 3% solution of the ether to the paper pulp gives satisfactory results.

As a result of its rather great solubility and of the reversibility of the color reaction, this oxidation indicator, alone, has restricted value as a forgery indicator and ought to be combined with other agents, especially with reduction and solvent indicators.

However, this oxidation indicator's great sensitivity even to weak oxidizers, and its strong color reaction are very valuable. Its solibility in oils also facilitates its use in oil-based printing inks, but not in those which are supposed to dry hard on the surface, because the dimethyl pyrogallol ether is a typical drying retardant.

There are still other possibilities along this line. For instance, beta-phenyl-alpha-naphthol in an alkaline solution changes to the violet diphenylbinaphthon when treated with oxidizers.

Benzol or napthaline carbonic acids, especially polyvalent poly-oxy-benzoic acids or poly-oxy-naphoic acids, even with weak oxidizers, yield brown to black oxidation products which cannot, or only with difficulty, be decolorized with reducing agents, according to US patent No 1864116, German patent No 582530, and British patent No 378694 awarded to V. Bausch and A. Schroth (Felix Schoeller und Bausch, Neu-Kaliss-Mecklenburg). The reduction likewise forms colored products, perhaps similar to phenol formaldehyde condensation products. Pyrogallic or gallic acid, to be sure, have previously been suggested for printing safety forms with invisible or colorless substances, but never for use in the beater to produce a safety paper. The latter is technically preferable, as a forger

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could remove printed characters with a rubber eraser. But a safety paper with the above-mentioned forgery indicators does not react with acids, and the script could be removed with, oxalic or citric acid for instance. To make the paper sensitive to these acids, iron oxide salts and lead ferrocyanide, both of which react to even weak acids by forming Prussian blue, should be added.

But it has been observed that gallic acid, in such a combination, and also under the influence of alkalies in the air, soon turns dark blue. The principle of iron gallate ink is based in part on this reaction. But if neutral derivatives of gallic acid -- for instance, pentagalloylglucose (tannin) -- are used, the acid effect can be avoided. But even these products turn brown when they are nearly neutral or in a weakly alkaline medium. This does not occur when the hydrogen ion concentration does not exceed a pH value of 4-5.5. On the other hand the acid reaction of the poly-oxy-benzoic acids can be reduced to a pH value of 3 by the addition of alkali, without producing the brown coloration in the presence of alkali.

Paper is treated with ferric acetate and lead ferrocyanide with a pH value of 4. A solution of equal parts of pentagolloylglucose and pyrogallol carbonic acid, whose pH value has been reduced with alkali to 3-3.5, is added. The dark coloration which this paper yields with oxidizers cannot be bleached out with sodium bisulfite.

On this kind of safety paper the script, or rather the dyestuff in the ink, is fixed to the fibers of the paper, according to V. T. Bausch, because tannin and similar substances act as very powerful mordants for dyestuffs. The purpose of this fixation is

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to render the script removable only by means of the stronger bleaches, so that writing with ordinary ink is almost as permanently fixed to the paper as if safety ink had been used. Any possible bleaching out of the ink writing would leave clear, practically indelible discolorations. These advantages are also aimed at in other, better safety papers. But good fixation of the ink dyestuffs -- rather, the forgery indicators -- to the paper fibers has an advantage insofar as the eliminating of the forgery indicators is concerned. The patent claim includes a large number of substances interesting from the viewpoint of protection against content forgery. Of the other poly-oxy-benzoic acids, the 3-5 dioxybenzoic acid should be mentioned. It forms acid and light-fast resoflavin even with ammonia persulfate. Nigrotinic acid (1.7-dioxynaphtaline-6-carbon-3-sulfo-acid), which with iron chloride forms a blue coloration (Inkset), and with hypochlorites a yellow-orange, should also be mentioned.

US patent No 1911774 (B. W. Smith, Todd Company, Inc., Rochester, N.Y.) recommends as forgery indicators p-p'-dihydroxydiphenyl (diphenol) or, in general, para-dioxy-compounds containing diphenyl or a similar group. Among these are, for example, p-p'dihydroxy-diphenylsulfide, p-p'dihydroxydiphenylthio-carbamide, etc, as well as their substitution products, analogues, homologues, and derivatives. Diphenol is to be preferred because it is cheap and easy to produce. It is added to the paper pulp or used to impregnate the paper in an alcohol solution or in the form of water soluble basic salts. The diphenol can be precipitated out of the alkaline solution with acids.

Sodium hypochlorite with diphenol turns an acid solution orange or brown and an alkaline solution deep black. Probably

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diphenoquinone is formed, from which the previously mentioned coerulignon is derived. But with a large excess of alkaline hypochlorite solution the black color can be removed again. Therefore diphenyl guanidines are used simultaneously. With the alkaline hypochlorite solution they produce a dark brown irreversible color, a lighter color with acid hypochlorite.

For impregnating papers, the sodium salts of the sulfonated diphenyl guanidines may be used, but without solvent indicators they are easily washed out of the paper.

A particular advantage of combining diphenol and diphenyl guanidine is that the paper may be dried warm without browning, which easily happens with the primary aromatic amines. Furthermore, valuable safety printing inks can be compounded with it (see pages 172 ff).

To make this combination of forgery indicators sensitive also to acids like oxalic acid, which might be used as solvents, it is suggested that alkali blue base or other colorless dyestuff bases be used with them. Alkali blue becomes colorless with diphenyl guanidine, magnesium oxide, or zinc oxide, but even with weak acids the blue color reforms immediately.

It is emphasized here that polynuclear aromatic compounds in which the hydroxygroups are not in the p position are useful as oxidation-forgery-indicators. Thus, for example, 2-6-dioxynaphthaline with oxidizers is changed into orange colored amphinaphthoquinone. And 1.5 dichloramphi-2,6-naphthoquinone is formed in a quite analogous manner. These substances themselves are strong oxidizers, a property which might be utilized in possible further safety measures.

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Although 1-5 dioxynaphthaline is stable to air, it rapidly changes into dark colored products when added to alkaline reagents or alkaline oxidizers.

Many more examples of similarly constituted substances could be adduced here, all of which are easily oxidized and undergo color reactions in the process. They have not yet been used as forgery indicators, perhaps because they are often difficult to obtain.

Below we shall give a comprehensive listing of V. T. Bausch's specifications which have to be met by any safety paper which is meant to furnish protection, especially against chemical eradication. These specifications are in accordance with the level of technological development which had been reached at the time (V. T. Bausch, Zahlungsverkehr and Bankbetrieb, 1932, page 18).

I. Sizing

The sizing of a safety paper should be such as to permit the ink to penetrate into the paper almost to the reverse side, but the sizing must not be so weak that ink spreads and strikes through the paper, giving the completed check an untidy and unpresentable appearance and a reverse side which cannot be legibly endorsed.

The weight of the paper shall not be less than 85 g per sq m, if possible, as with the relatively stronger sizing necessary in lighter papers the ink does not penetrate sufficiently into the paper stock and attaches itself inadequately to the fibers. A thicker paper can be more weakly sized without fear that the script will strike through to the reverse. Furthermore, a thicker paper presents a better foundation for the reagents to be incorporated; a relatively and absolutely greater quantity of reagents can be incorporated

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into a thicker paper. This contributes materially to its increased ability to react, and to the fixation of the script.

In practice it is scarcely possible to keep the sizing of a paper stock completely uniform throughout the production process. The paper mill therefore must be careful to keep the sizing rather too weak than too strong. A paper with too little sizing may look ugly when written upon, but a paper with too much sizing is dangerous. This is especially true if lighter papers must be used for reasons other than protection.

II. Stability of Writing Ink on the Paper

The tighter the ink dyestuff is attached to the paper, i.e., the tighter it is fixed or adsorbed, chemically and physically, to the fibers of the paper, the more difficult and especially the more tedious are mechanical or chemical erasures, which, if not impossible to perform, will leave obvious traces.

Test for Ink Stability to Chemical Erasure

On the papers to be tested, draw a line, not too thick, with a uniform pressure and a pen that does not scratch. Blot it after 10 seconds. Cover the line with a fresh 2% solution of potassium permanganate. Blot it after 10-20 seconds and remove the permanganate spot (or any color reaction from oxidation) with a bisulfite solution. The line should not disappear, but if it does, an ineradicable reaction spot must be left.

III. Sensitivity to Chemical Eradicators

All color reactions should be darker than the surrounding paper, or at least should appear to be of a substantially different

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color by transmitted light. The color reactions should not be merely superficial, but should penetrate into the paper -- if possible, to the reverse side. Mere bleaching of an incorporated, coated, or printed color is not a color reaction: white or light colored bleached areas can be manually recolored without difficulty. Complexity of the color reaction and ineradicability of the discoloration by chemical agents which oppose the reaction and thus compensate for the agent first employed, are essential. The safety paper must not only make successful forgery impossible but must also clearly indicate the first step of an intended forgery.

A. General Reactions

1. Color reaction of weak acids.

Example: A 10% solution of oxalic acid or 2% sulfuric acid, which upon treatment with (weak) alkalis cannot be corrected, or only with the formation of a new ineradicable color reaction.

2. Color reaction on weak alkalis, preferably ammonia which, when treated with acids or bleaching oxidizing agents (chlorine), cannot be reversed.

3. Color reaction on oxidizing agents, preferably hypochlorite solutions, or molar chloride, which when treated with reducing agents (e.g., bisulfite or hydrosulfite) cannot be reversed; or which, when treated with reducing agents, is transformed into a differently colored reduction product. It is essential that, insofar as the ink writing is removed by means of oxidizers, upon subsequent treatment with reducing agents, such as hydrosulfite, a prominent spot or ring be left indicating the attempted erasure.

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B. Special Reactions

1. Liquid ink erasers with a permanganate basis without acid, such as Korrektor, Italina, Extinkt, etc, which consist of a weak sulfate solution with approximately 3% potassium permanganate and a bi- or hydrosulfite solution (2 bottles only). These eradicators are the most dangerous, as they remove fountain pen inks as well as normal ink writing that is not too old, without leaving noticeable traces of the reaction (not even by ultraviolet light, if the chemicals are skilfully handled).

Even if the writing is fresh and the eradicants are applied several times in succession, it may not be possible to obliterate the writing without leaving conspicuous traces.

2. Ineradicable color reaction of ammonia.

Older ink script is "attacked" by ammonia and rendered more "susceptible" to the bleaching action of chlorine. Ammonia is used particularly in order to compensate for any acid properties in the various chemicals used for ink eradication, which might react with an acid-sensitive paper, and to compensate for any discoloration which might have taken place as a result of an acid reaction.

In most cases the forger will first attempt to dissolve the script with dilute acid (peptize it). He will attempt to correct or compensate for the nascent acid reaction, preferably with ammonia, as this alkali evaporates immediately and leaves no after-effects on the paper. For this reason the sensitivity of safety paper to ammonia -- and to the weakest alkali -- is an essential requirement.

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3. Ineradicable color reaction with soap solution and spirits of soap, which have been variously used for the removal (washing off) of ordinary stamp-pad inks used for hand-stamped cancellations. This reaction is particularly important in the case of stock certificates, bonds, titles, etc, and letters of credit. The latter are occasionally inscribed with India ink or so-called safety inks which are not attached by chemicals and can be washed out with soap solution or spirits of soap.

To prevent the counterfeiting of whole forms, blanks, documents, etc the paper should have a "double action" watermark.

These requirements for a good safety paper could be supplemented in various ways. Thus, professor G. Koegel in his book Die unsichtbaren Strahlen im Dienste der Kriminalistik [Invisible Rays in the Service of Criminology],(U. Moser Publishing Company, 1928, Graz) page 160, recommends that banks, officials, etc, select fluorescent paper, "because it makes it considerably easier to detect erasures, falsified numerals, rubber stamp impressions, signatures, and special pencil or crayon marks. The officials will more readily decide to try it if the paper industry will supply it. Since, as is known, official regulations have been issued governing the quality of the paper, why not issue regulations to cover the safety characteristics of the paper at the same time? Crime would decrease, as would the work load of security agents and offices.

G. Koegel here recommends the use in papers of fluorescence in ultraviolet light not as a mark of authenticity, but as a forgery indicator -- perhaps one of the most refined indicators at our disposal today. While the principle of exposing chemical forgery is based on the incorporation in the paper of substances which produce

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a color reaction with chemicals in the ink eradicator, in the ultra-violet-fluorescence principle an attempted forgery is generally scarcely noticeable or quite imperceptible initially, and does not become apparent until the object is investigated under ultra-violet light under certain conditions. In addition, this process has the advantage that in most cases the object undergoes no alteration whatever. Hence it meets one of the most important principles of judicial investigative practice, namely that, insofar as possible, the object investigated must be preserved in its original state.

Against these advantages, the process of signalizing content forgery by ultraviolet fluorescence has the disadvantage of requiring complicated and expensive investigation methods and apparatus (photography is often necessary). Carrying out an investigation may take a long time, which makes this method hardly suitable for banking operations. But the use of fluorescent safety paper makes it much easier to establish content forgery by ultraviolet light and it certainly would be very difficult for a forger to perform an erasure without leaving traces visible in ultraviolet light.

As a rule it is not necessary to dye the object to be investigated in order to render the chemical erasure visible. Whether Koegel's positive or negative method be used or the dyeing process with eosin or quinine as suggested by R. Mellet and A. Bischoff, (Comptes rendues 181, 1925, page 868), they are hardly suitable for banking operations. It is much more effective to incorporate the substances in the paper during the course of manufacture, and to protect them from being washed out by providing the paper with a solvent indicator. Quinine is particularly interesting as a

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forgery -- i.e., fluorescence -- indicator. If an acid is neutralized by means of a lye in the presence of a trace of quinine, the fluorescence ceases but returns when an acid is added.

Chapter IV. Safeguarding Personal Identification

Forgery-proofing protects only against alteration of the contents of a document; counterfeit-proofing against imitation of the document. Together they do not suffice to rule out all possibilities of falsification, especially not the falsification of identity, i.e., the falsification of a distinctive, personal, identifying mark. A forger, for example, can take a genuine check blank which is completely protected against counterfeiting and forgery, fill it out and sign it (signatures are notoriously easy to imitate) with the imitated signature of someone else -- that of the owner of the checkbook, for instance. In this case, most safeguards against counterfeiting and forgery are useless. In order to exclude also this possibility of fraud, various safeguards have been employed, notably signature safeguards. But signatures are very easy to imitate, and there are people who possess an unbelievable skill at imitating them. Special signature inks may be used in connection with the principle of chemical proof of identity, codes, secret symbols, etc. All these methods are feasible and in most cases render the task of the forger more difficult. But they by no means offer assurance that the signature is genuine -- that the expression of intent conveyed by the check is indubitably that of the person indicated by the signature. Furthermore, the methods cited are largely impracticable. They could be used in isolated cases, but not by the great mass of people with checking accounts.

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To create a usable proof of identity a distinctive feature would have to be employed, one characteristic of a single individual and of no other. Photography and fingerprinting are well-known examples providing such identifying characteristics. Both are widely used by the police for identification purposes.

Photography, however, is too complicated for checks and similar purposes, and not secure enough, as photographic techniques are, so to speak, generally known. It could perhaps be used in connection with travelers' checks: a portion of the check could be covered with a photographic emulsion upon which a photograph of the owner is printed. If the best anticounterfeiting measures are used along with safeguards against removal and substitution of the photographic emulsion, a certain degree of security of identity will be achieved. But if the forger procures a photograph of the person in question and also succeeds in procuring an undeveloped blank form, falsification of identity is easily accomplished even in this case.

The use of fingerprints would be very promising in connection with the safeguarding of personal identity, and attention is invited to the following argument on the subject by E. Locard, a widely known authority in the field of scientific police work.

At any rate, fingerprints, used in suitable form on travelers' checks, money orders, tourist drafts, letters of credit, and similar negotiable papers, would be infinitely more secure than the safeguards employed today. In the case of travelers' checks, for instance, it is customary that the buyer sign at the upper left under the note which reads, "When countersigned below with this signature." In presenting the check to the bank cashier for payment,

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the holder is required to sign it once more, whereupon the cashier compared the 2 signatures for authenticity. This kind of safeguard is thoroughly inadequate, as a practiced forger can train himself to imitate any given signature exactly and quickly enough. In fact, travelers' checks are frequently forged.

For the identification of fingerprints we refer to the works of E. Locard. A fingerprint can be checked almost as quickly and easily as a signature. The probability that 2 persons with the same fingerprint can be found is extraordinarily slight; it has never yet occurred in police operations.

New York police officials recently appealed to the citizenry to register their fingerprints at the identification offices in order to make possible positive identification in case of murder, and also to establish the authenticity of wills. Several thousand New Yorkers, especially those of the more wealthy classes, responded to the appeal. Fingerprints will probably become very important to protective technology in the future.

Chapter V. Fingerprints as Signatures on Negotiables

Edmond Locard, Director,
Police Technical Laboratory, Lyon

The signature, with or without paraph, has been considered the normal symbol of identity since writing began. This is the reason why signatures of special importance are often extremely complicated. Those of the French notaries of the eighteenth century and those of Arab officials today are examples. At the museum of criminology at Lyon we have specimens of Moroccan or Syrian signatures which discourage attempts at imitation. In practice, however,

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persons who must sign their names repeatedly have a tendency to simplify their signatures to the extreme. This holds true for the majority of bankers and heads of industrial firms. It must be admitted that under these conditions the signature loses virtually all its value as a mark of identity.

It was therefore natural to try to assure the authenticity of negotiable instruments by replacing this rather inefficacious symbol with some other symbol representing the individual. Even in antiquity the Assyrians used the mark of the fingernail (see Traite de criminalistique, Vol II, page 595), the Greeks utilized the seal, the Chinese and the Hindus the print of the whole finger (not taking account of the ridges on the finger tips, as has been mistakenly stated). It was quite natural that modern research on dactyloscopy should have led to the utilization of the finger-tip ridges as proof of identity. In fact a number of proposals have been made in various countries to adopt the use of fingerprints on legal and commercial documents. For details I can only refer the reader to my book, Traite de criminalistique (Vol I, pages 485 ff.). I only wish to point out here that thus far South America alone has turned theory into practice.

Two kinds of objections have been made to the use of fingerprints on negotiable instruments.

(1) It is difficult to ask clients to have their fingerprints taken. You cannot ask persons concluding commercial transactions to soil their fingers with greasy printer's ink. This is self-evident. But it is not conclusive. I am not the only one who has demonstrated how simple it would be to roll the finger, without ink, over smooth paper or cardboard, then to develop these prints

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with a powder such as antimony sulfide, antimony black, or gray lead oxide, and fix the print with an ordinary fixative. The whole proceedure would cost neither time nor money.

(2) The second objection is that false fingerprints are possible. There was a memorable and violent argument on this point in the United States in 1924. I regret to say that the campaign was inspired by self-styled graphologists reluctant to lose the living they were earning by producing false signatures. Actually, the production of false fingerprints, if not theoretically impossible, is impracticable. In any case it is amusing to compare the probability of a false print with that of a false signature.

It would certainly be extremely desirable to substitute fingerprints for signatures on checks, notes, commercial instruments, identity papers, and even on stock certificates. It will be accompli-shed easily and quickly once the public divests itself of its prejudices and ceases to regard the taking of fingerprints as an operation connected with the police -- not to say with imprisonment.

Chapter VI. Graphic Safety Techniques

The technology of reproduction is concerned with providing a finished paper with a definite patterning, using various processes usually divided into printing, engraving, the flat processes, combination processes, and embossing. Farmiliarity with these processes is assumed, and the following discussion is primarily concerned with the security measures now employed or employable.

Among all safety techniques, those concerned with the reproduction techniques are still by far the most important because they provide an extremely high degree of counterfeit-proofing.

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There are also economic reasons for this because the graphic processes make it possible to deliver distinctively executed stock certificates, bonds, checks, etc in any small quantity (and small quantities usually are called for). For economical reasons this is usually impossible for the papermaker.

The safest graphic process is the one which on the one hand contains the most production difficulties -- that is, in which the patternings produced are the most difficult to copy in all their details -- and, on the other hand, is the least widely used. Furthermore, the more complicated and expensive the machinery and apparatus required for its execution, the more secure the process.

Certain forms of engraving are generally considered to have high claims to safety, particularly copper plate printing also called copper engraving or etching, and steel engraving, which is similar. The execution of the plates for this process is tedious and therefore very expensive, and demands a personal artistic skill difficult to find these days. Making impressions from the plate also is a very special process, which likewise requires long experience. No process can yield such fine lines, so extraordinarily close together, as steel engraving. Such lines and hatchings can scarcely be reproduced faithfully, and as sharply as the originals, by means of photography one of the most important tools of the bank note and stock certificate counterfeiter. This is true especially if other safeguards against photographic reproduction, such as a background impression, etc, are incorporated as well. Steel and copper engraving also permit the production of wide differences in color (tonal variations) in one and the same line, because the deeper the engraved line upon the plate, the more ink is deposited on the paper; more precisely, the higher

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the relief of the ink upon the paper. This provides another very good safeguard against photographic reproduction. For these reasons the better bank notes are still produced by these engraving processes -- and mostly by government printing establishments, some of which, furthermore, have developed procedures of their own.

The letterpress process -- especially the so-called line etching (and most of all glass etching) -- also produces extraordinarily fine hatchings. According to the regulations of the admission office of the Berlin Stock Exchange, which apply to most other German admission offices, paragraphs a to 7 of the regulations issued on April 13, 1927, only good letterpress or copper engraving may be used for negotiable papers to be traded on the Exchange. Flat processes will not be used under any circumstances (lithography, zinc lithography, aluminum lithography, offset, rotogravure, the Manul and Obral printing processes, photogravure, collotype, etc.)

All graphic processes that use screens, such as autotype heliogravure, copper-plate printing, doctor ["Rakel"] intaglio printing, etc, are prohibited because they facilitate photographic reproduction. (The regulations of the Berlin Stock Exchange have been called too sweeping by many graphic specialists, such as K. Hazura of Vienna, Walther, and others. From a security standpoint, however, they should be hailed without any doubt.

Postage stamps, negotiable instruments and similar products of the usual screen gravure processes, whether with irregular grain or regular dot pattern, are unsatisfactory from a security point of view also because the fine details, even with a very fine screen, usually come out blurred. It has therefore been suggested

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that the screen should be applied to the lines of the design -- manually or by machine -- in such a way that the screen pattern is always at right angles to the line, or nearly so. A still better result is supposed to be achieved more easily if the printer's cut is divided up not by means of the usual screen, but according to German patent No 446656 (A. Nefgen, Godesberg, on the Rhine).

In this process the elements which are to serve as matrix for the doctor intaglio plate are laid by hand, or with tools like rubber stamps, etc, into the original to be reproduced. The large-scale original is thus partitioned off by means of all kinds of elements -- surfaces, lines, or shapes of any kind -- which will stand out in relief after the printer's cut is etched, thus serving as a matrix for the doctor plate. This breaking up of the design is done in such a way that it is not apparent in the printer's cut, or in the finished product, and constitutes the uniqueness of the latter.

As a check on the authenticity of the product, pictorial elements of any kind, known only to the initiated, may be inserted in the printer's cut.

Original drawings of this kind are of course copied photographically, and a negative and a positive -- usually reduced in size -- are made. The positive is printed on pigmented paper.

As the distribution of the printing elements has already been made in the original, as described above, it is not necessary in this process to photograph it through a screen of any kind. The remainder of the process is normal. The pigmented positive copy is etched as usual and the printer's cut, cylindrical or flat, is printed in the usual press.

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The results achieved with the printer's cut described above resemble copper engravings. Contrasted with the usual copper engraving, this modified intaglio or gravure process yields considerably higher production speed. The production capacity of copper engraving for negotiable papers has been considerably improved. Production techniques with the newer machines are described by Hazura. See also British patent No 241470 (Hoe and Company); 217819; 220842; 233551; 235008 (for gummed paper -- postage stamps), and 236719 (American Bank Note Company).

Like the previously named safety measures, a number of other safety printing processes are based on the difficulties of production itself. In most graphic processes, a perfect register, i.e., perfect superposition of the individual printing plates is most difficult to achieve. While the industry has taken great strides in this direction, the maintenance of perfect register still depends on various factors, such as paper, machine, technique, which in most printing offices are inadequate or not fully satisfactory. The following processes depend partially on perfect register. They serve to assure authenticity, and, if properly used, constitute forgery-proofing as well.

According to German patent No 62053 (A. B. Drautz, Stuttgart) documents such as bank notes, etc, are imprinted on both sides with exactly symmetrical designs. The colors are the same, but applied in reverse order, so that, the two impressions being precisely superposed, only one color will be visible by transmitted light -- the combination or fusion color from both sides. It is clear that in such a process principally transparent colors must be used. The principle is explained in a few words by means of the following example.

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On the front, for example, are printed the letters A B. A is in transparent yellow, B in light Prussian blue. On the reverse, the same letters are printed (in reverse), so that by transmitted light they appear as single units. But A is printed (on the back) in the same light blue, as B was printed in on the front; while B on the back is printed in the same transparent yellow as was used for A on the front. While A appears yellow by reflected light, on the front, and blue on the back, it is green by transmitted light. B is likewise green by transmitted light, but by reflected light is blue on the front and yellow on the back.

Applying and adjusting the second plate, feeding the paper in such a way that the colors and figures are exactly superposed, and choosing the colors are matters which require practice. Such press work can be carried out only in a printing shop with excellent presses and skilled personnel. The preparation of the 2 engraved plates which must be identical also demands extraordinarily precise workmanship, as the slightest variations between them comes to light at once on paper printed on both sides with identical figures but in different colors.

The production of precisely superimposed plates is particularly difficult when obverse and reverse must be printed in 2 separate printings. Then the variations in size of the paper and the difficulties in feeding it into the press must be reckoned with. The difficulties are further accentuated by the fineness of the design.

According to German patent No 338333 (Poensgen and Heyer, Letmathe, Westphalia), the photographic tracing process is used to produce exactly superimposed patterns on both sides of a sheet of paper.

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This has the advantage that by transmitted light the 2 designs are precisely superimposed, so that even the finest drawings may be utilized. A further advantage lies in the greater sensitivity of the paper to fraudulent attacks. The paper prepared for the photo-tracing process is highly sensitive to erasures and attacks by corrosives, and the restoration of the pattern, especially the color tones, is extraordinarily difficult if not impossible, so that the attacked areas are immediately recognizable in transmitted light. The paper is prepared in the following manner.

From the negative of a printing plate a reversed negative is made by contact printing; consequently, the patterns on the 2 photographic printing plates are identical. The 2 photographic printing plates are set into a single copying frame, which ensures the exact superimposition of the patterns of the 2 plates. The prepared, light-sensitive paper is placed between the 2 negatives in sheet form or fed through in rolls. After exposure to light it is fixed in the usual way.

This is not the place to go into the numerous photocopying processes already fully described by various authors. All these processes, in one way or another employ substances which are highly sensitive to corrosives. The newer processes, such as Ozalid (see Eder, Die Pigmentverfahren [The Pigment Processes], and Wandrowsky, Die Lichtpausverfahren [The Phototracing Processes] also use dyes which are usually highly sensitive to corrosives. These latter processes would be the more suitable for safety papers as the fabrication of the light-sensitive diazo substances often is quite difficult. On the other hand, it is disadvantageous from the standpoint of safety that such diazo substances are already

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available commercially. Best for safety purposes would be a new kind of secret process based on materials that are difficult to produce.

Identical superimposed drawings that are chemically highly sensitive, and appear on both sides of the paper have the advantage that in case of chemical or mechanical erasure -- on the front, for example -- the design would still be preserved on the back, and in all probability it would be impossible to reconstruct the design on the front to match that on the back.

US patent No 1692645 (L. Gailer, E. E. Lloyd Paper Company, Chicago) contains the description of the manufacture of a safety paper that is dyed and printed simultaneously, front and back, in perfect register -- all in one single operation. The coloration is so chosen that it reacts against chemical corrosives.

The paper is conducted through a dye bath, dyeing both sides. Depending on the strength of the sizing, the dye penetrates into the interior of the paper stock to a greater or lesser extent. After the dye bath, the paper passes between 2 wringer rolls, one or both of which may be provided with an intaglio plate or any other kind of printing plate. Thus on the front and back of the paper appear imprints in perfect register, in the same color as that of the paper, from which they differ only in being lighter or darker, as the case may be. If parts of the paper are treated with corrosives, acids, etc, not only the paper color but also the designs are affected.

Several variations of this process are possible. For example, the paper may be stamped with characters or designs in relief, before dyeing, which would give a similar effect after dyeing.

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From the point of view of protection, such a paper has an advantage over paper imprinted with ordinary printing inks based on linseed oil namely, that the printed characters are very easily attacked by chemicals and that a forger would find it difficult correctly to restore characters on one side because of the existing duplicates in exact register on the other. The difficulty, however, is based primarily on the fineness of the drawing; guilloche ornaments would be most useful here. A further advantage is that the paper is simple and cheap to produce. Check forms may be produced in one continuous process by this method.

A flat bed press for the production of multicolored work for textured backgrounds for bank notes, stock certificates and the like which guarantees the necessary maintenance of perfect register, is described in British patent No 4429 (1915) (Whitehead, Morris and Company, and P. Morris, London). The previously inked color printing plates are applied one after another to the paper which is attached to a table. The plates are held in position by an electromagnet, which guarantees perfect register. In this process -- unlike the usual process for multicolor printing in which a single color is printed in the entire edition before the next color -- all the colors are printed on the stationary sheet of paper, one after the other, and the paper is not replaced until it is completely printed. Of course all the inks except the last must be quick-drying if any kind of profitable production is to be achieved.

What color inks are most suitable for safety printing? It would be best to differentiate the colors according to the purpose of the document for which they are to be used.

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1. Bank notes, stock certificates, mortgage deeds, bonds and similar documents, for which counterfeiting is the greatest danger.

2. Checks, letters of credit, receipts, etc, which are subject to forgery as well as to counterfeiting.

The colors of documents of the first class must be as durable and light-fast as possible, as befits the character of the document itself. Such documents must be protected against the various kinds of counterfeiting -- manually and particularly photographically. The first-named properties are not peculiar to safety printing colors; light-fast ink colors are used for many other purposes in the printing industry. Manual reproduction is prevented mainly by means of the quality of the printing and of the pattern. Interfering with photographic reproduction, however, is a very definite requirement for the colors to be used.

For this reason, methods of protecting against photomechanical reproduction will be dealt with in somewhat greater detail. For complete understanding, the reader should be generally familiar with the photomechanical processes.

To make a faithful reproduction of a colored original, 3-color and 4-color photography is generally used. In outline, the process consists in making 3 or more photographs of the colored object, each with one of the primary colors (yellow, red, blue) on the photographic plate, the other 2 primaries being excluded. The 3 or more partial negatives thus obtained are used to make the color impression plates. Exclusion of colors from the negatives results from the use of selective filters which pass one range of rays but absorb all the rest.

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If a colored picture is viewed through a violet colored filter (such as a solution of a violet colored dyestuff), all the yellows in the picture will appear black, the more or less yellowish will appear orange, and the greens will appear gray. The violet elements of the picture will remain violet and the blues will perhaps turn somewhat more reddish. In the same way, an orange colored filter will exclude the blues and bluish shades; while a green filter will exclude the reds and reddish hues. Now if a photograph is made with a selective filter, the photographic plate will be affected by the rays which fall on it, but not by those which were absorbed by the selective filter, and which through the filter appeared black to the eye. These latter areas will thus be colorless -- or transparent -- on the developed photographic plate, while the rays falling on the plate will appear more or less black -- assuming that the photographic plate is sensitive to these rays. Behind the violet filter a photographic negative will be produced on which the yellows are transparent, the yellowish tones more or less darkened, and all the rest dark, or black. This photographic negative now can be retouched, if necessary, and used directly or indirectly for the preparation of the yellow impression plate by one of the photomechanical platemaking processes. The impression plate is prepared in such a way that the areas which were transparent on the photographic negative are those which apply printing ink to the paper. The violet filter is used to make the yellow impression plate, the orange for the blue, and the green for the red. To make the black plate (4-color process), a weak yellow filter is usually used -- especially when the black in the original is bluish -- or no filter at all. Here a photographic emulsion sensitive to all colors must be used. By superimposing the impressions from these

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plates -- using the so-called primary colors: yellow, red, and blue -- a more or less successful reproduction of the original is produced. If the original is indefinite, the plates must be divided up into printing dots by means of a screen (autotypy) because of the mechanical inking of the plates.

As noted above, the photographic emulsion must be sensitive to the rays that fall on it. The usual, nonorthochromatic silver bromide as well as the wet collodium of the plate (important in the reproduction process) are sensitive only to blue, violet, and ultraviolet rays. A photograph made with such material reproduces the tonal values of the individual colors in the black-white scale falsely, as the eye does not perceive blue, but yellow, as the lightest color. Thus, if a black line drawing on a yellow-dyed paper is photographed by the wet collodium plate process (which process reproduces the lines of a line drawing most sharply), an extremely weak, useless picture -- or none at all -- results, because no light rays reached the emulsion. The same is true if a violet filter is used. For this reason yellow paper could be used to prevent photomechanical reproduction until there were yellow-sensitive photographic emulsions.

In 1873 H. W. Vogel discovered that the silver bromide emulsion could be made sensitive to other colors besides blue and violet by adding dyestuffs such as erythrosine, eosin, etc. These so-called orthochromatic photographic emulsions are sensitive principally to blue and violet, and to a lesser degree also to yellow and green. With these, therefore, the black line drawing on yellow paper could be reproduced.

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But the orthochromatic emulsions are not sensitive to red, and for this reason such plates were developed in red darkroom light, as is familiar to everyone who has occupied himself practically with photography. By the addition of further dyestuffs, orthochromatic emulsions become sensitive also to red and orange, thus producing a material which is sensitive to practically all visible rays, and which is therefore called panchromatic. These panchromatic emulsions are used primarily in 3 and 4-color photography for purposes of reproduction.

Color photoreproduction processes today have reached a high level of perfection through the use of suitable color filters and color-sensitive photographic emulsions. And by varying the basic 3-color photographic process by means of special filters, negatives with highly pronounced color separation can be produced. If the original to be reproduced has a narrow range of color variation, for instance a dark, medium, and light olive, even these differences can be reproduced either in the negative, by appropriate masking of the various areas, or by the use of smaller or larger dots in the screening photograph. In the half-tone process lighter and darker areas in the same color are of course reproduced with one and the same ink by utilizing the optical effect of smaller and larger dots. For this reason a half-tone is relatively easy to reproduce photomechanically. But because of the double-screen effect a half-tone copied from another half-tone is not a thing of beauty. But the copyist can improve the original by touching it up with opaque watercolor before photographing it. He must also avoid the "moire" effect, for which the regular engraver's tools are at his disposal. For these reasons it will be understood that the half-tone process -- in fact all reproduction processes in

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which the printing surface is broken up into points by means of a screen -- is not to be recommended from a security point of view if it is to be used alone. It must be admitted that the best half-tone reproductions with perfectly clean dots are difficult to imitate in all their details, but the determination of this difference between genuine and spurious documents is not to be expected of the majority of those using them.

But if the original of a bank note, for instance, consists of fine line drawings whose individual lines vary only slightly in color, enormous or even insuperable obstacles confront the reproduction photographer or the forger. No matter what filters or photographic materials he may use, he will always get a negative that contains all the lines with all their tiny color differences. As the individual lines of the same color must be printed with their own special plate, the forger must see to it that these lines are held apart on the photographic negative. And this is not possible in color photography if many lines lie close together in the original, with only relatively slight color differences. Then the forger must resort to retouching the negative or a transparency, drawing, scraping away, and other manual manipulations, in order to remove or cancel out unwanted elements, and to reinforce others. Retouching can only be done successfully by a highly experienced retoucher, with a certain amount of artistic skill. It becomes the more difficult as the hatchings of the original are finer, as the lines are closer together (to a certain degree), and as the individual lines are finer. But this holds good only up to a certain point, as the lines must not be too close together -- as will be explained later. Hatchings of slightly varying color nuances printed over one another are darker where the lines cross, when transparent

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inks are used, and difficult to reproduce exactly by means of retouching. From the preceding it is evident that protection against photomechanical reproduction is based primarily on the choice of colors. They must be chosen in such a way that the copy-photographer will always have as many as possible of the colors on his negative simultaneously, no matter what filters or plates he may use; and that thus the labor of the retoucher will be as complicated as possible. In conclusion, the appropriate safety measures against photomechanical reproduction to be taken are recapitulated as follows.

1. There should be on one and the same document several hatched areas printed with various plates and difficult to imitate by hand. They should differ relatively slightly in color but still with clearly perceptible differences of nuance. These hatchings always appear simultaneously on a photographic negative and require retouching, which in certain circumstances is impossible.

2. The colors referred to in (1), above, must not be pure, bright colors. A clear, bright blue or blue-violet is to be avoided because it can easily be isolated with the wet collodion plate process. Clear reds are likewise dangerous as they can be isolated with red-sensitized wet collodion emulsion plates. So-called dirty colors such as dull red, olive, or brown, on the other hand, are very useful. Dirty colors lying near each other in the spectrum, and not complementary colors which are easily isolated photographically should be chosen as a rule. Hatchings made with these colors should be distributed over the entire document or should run over into all its pictorial elements. When this is done, the pattern is called a background. The most prominent

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elements, like guilloches, should be printed in similar colors. For further protection a safety printing network of fine lines in black can be applied uniformly over the whole paper. Black is likewise difficult to separate from the colors described above and thus increases the retoucher's difficulties.

3. Instead of printing each dull color with a special plate, one and the same plate can be inked in several areas with different colors (see the discussion of related processes in this book). In so doing these colors should also be chosen in such a way as to make photographic isolation difficult. But an imitation of such printing with separate plates is possible, if difficult, to attain with perfect register. The individual hatchings may also contain fine color transitions, which is of course possible in steel and copper-engraving using transparent colors.

4. The chemical composition of the safety printing, background, and principal elements must be such that they cannot be altered, chemically or physically, in such a way that they can be easily isolated photographically.

Chrome yellow, Milori blue, ultramarine, lithopone and other colors can be transformed into black by means of chemical operations, whereupon under certain conditions it is possible to isolate and record lines in those colors photographically. Whether it can be done depends primarily on the other lines and colors in the original. Under the influence of acids ultramarine becomes colorless, so that line drawings in ultramarine alone can easily be removed from the original. As the individual lines react very differently to ultraviolet, x-rays and infrared light, it is possible to isolate colors by these physical means. It appears that this

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possibility has not been given adequate attention in safety technology thus far. The possibility can be ruled out if all the printing inks contain the same pigments in different proportions, or if the whole document or all the inks are so treated that they react uniformly to invisible rays.

The inks can also be changed by purely physical means by simply eliminating them from the document with suitable solvents, or by covering them with suitable printing inks. These few hints indicate adequately that in any given case the greatest caution is required in the choice and combination of printing inks to protect documents against photomechanical copying processes. In addition there are the purely printing requirements such inks must fulfill. These requirements vary widely according to the reproduction process. Above all, the inks must print well in order to produce the sharpness and continuity of line so important in safety technology. There are many other graphic requirements which, however, are requirements of the individual processes themselves and therefore cannot be discussed further at this point. A compilation of more or less suitable inks, printing-ink oils, varnishes, and other graphic methods has been published by K. Hazura in his chapter entitled "Inks for Printing Valuable Documents," in H. Hadert's Handbuch ueber die Herstellung und Verwendung der Druckfarben [Handbook of the Manufacture and Use of Printing Inks].

Inks can also be used to produce effects similar to watermarks, and thus contribute to counterfeit-proofing.

In addition to the method mentioned earlier, imitation watermarks can also be produced by imprinting the paper at appropriate places with substances that make it more or less translucent. This is a favorite procedure of forgers.

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According to German patent No 183888 (Eders Jahrbuch [Eders Annual], 1908, page 567), paper may be imprinted with wax, paraffin, etc, by placing the paper and a tape saturated with the substance between 2 heated dies. The heat of the dies melts the material, which is partially transferred to the paper. The process is similar to gold-stamping as practiced in bookbinderies.

Several ink manufacturers are selling watermark inks which can be imprinted directly on the paper by any of the graphic processes, to give a watermark effect wherever they are printed. For instance, the Horstmann-Steinberg Dye Works, Celle, have devised such a product for letterpress printing and lithography. (Eders Jahrbuch, 1914, page 454).

The Superior Printing Ink Company Inc., New York City, also sells a watermark ink which can be used in letterpress printing in the usual way. It does not require any additional equipment and, once applied, can be written upon in ink. Unusually thick papers should be imprinted on both sides. The printing ink factory of Hartmann Bros., Halle/Ammendorf, likewise sells watermark inks Nos 724 and 725 for letterpress and lithography.

Austrian patent No 77088 (G. Ruth, Wandsbeck-Hamburg) protects a watermark ink which is made by dissolving 50 parts stearin in 200 parts heated printer's ink varnish and adding 300 parts of the varnish, 40 parts cod liver oil, 5-10 parts spirits of turpentine or volatile mineral oil, and about 4 parts Bolognese chalk.

It is evident that there are a very large number of possible combinations of elements that can be used in the manufacture of such watermark inks. They can also be made with an aqueous base or

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by combining alkali-resistant resins either with varnish (such as wood-oil varnish) or with mineral oils, etc, in such a way that they withstand the concentrated sodium hydroxide test for genuine watermarks. (Genuine watermarks remaining are not affected by this test; imitations either disappear after a period of time, or remain visible). These imitations, then, react to this test as would genuine watermarks. It is no problem for an experienced printer to make an ink that can be written on in ink; it is general knowledge in the printing industry that Bolognese chalk, i.e., precipitated calcium carbonate, is used for this purpose.

The printed watermark has been adopted in practice primarily because the papermaker often is unable to meet the customers' demands for small quantities of paper with individual watermarks. Most mills do not produce less than about a ton of a given paper.

But because the printed imitation watermarks described can be so easily imitated by counterfeiters, it would be well to add counterfeit-proofing elements. First of all comes the principle of chemical marks of authenticity. For example, forgery indicators could be added to the watermark inks which would react, say, with chloride of lime, or other chemicals with certain reactions to specific reagents might be added. These indicators could also be imprinted upon an ordinary printed watermark, perhaps by using a half-tone cut and an invisible ink which becomes visible in ultraviolet light. The counterfeiter would, under certain conditions never guess that the overprint existed.

For example, according to British patent No 390188 (I. G. Farben Industries), hydrocarbons can be made fluorescent by adding small quantities of, for instance, 0.05% amino-2-phenylbenzazole,

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perylene or perylene derivatives. The principle could be used for watermark inks, especially if one could add substances that are colorless in ordinary light but which fluoresce in ultraviolet light. This method should be particularly suited to stock certificates and dividend coupons.

Incidentally, the quartz lamp also makes it easy to distinguish between genuine watermarks and printed imitations.

According to German patent No 62052 of A. B. Drautz, Stuttgart, whose process leans heavily on fabric printing methods, a sort of mixed paper is prepared with added fibers which have been dyed with stable or sensitive dyes, depending on the purpose the paper is to serve. The watermark is then printed on the paper -- before it is sized -- with gummed watercolors containing mordants or corrosives. Thereupon the added fibers in the body of the paper stock are altered in such a way that they appear white on a colored ground; or the ground is imprinted and the watermark appears colored on a white ground. The process aims at preventing both counterfeiting and forgery. Further details cannot be given here, especially because the formulas given are long out of date and the process has no great safety advantages over the mixed papers. In addition, the processes for achieving such watermarks are widely known even in lay circles. The counterfeiter can also produce the same watermark with ink eradicators.

To ensure genuineness, friction-sensitive dyes also can be used, i.e., dyes which, when rubbed with a hard object or even with a fingernail, change color. They are made in various ways. Oil colors, for instance, can be made sensitive to friction by adding coarse but crushable dyestuffs while the finely ground colors

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usually used in printing inks are omitted or kept to a minimum. A light green oil color like that composed of Prussian blue, Hansa green 10 G, and Lithopone will turn yellower when rubbed, if the colors are not finely ground and if the oil medium does not dry hard. Furthermore, most of the inks made with aqueous media and colored pigments, for example those used on a large scale in the colored paper industry for coating paper, are sensitive to friction, especially if a wax emulsion is added. An ordinary light-blue glazed paper for example becomes shiny and turns deep blue where it is rubbed with a fingernail. Argentine (very finely divided tin powder), coated or printed on paper in starch paste or some other watery medium, dries to a light gray, matte color which assumes the color and gloss of silver when rubbed.

In Austrian patent No 10301 L. Lebateux of Paris notes that a printing ink made of lead white or zinc white, into which fat or oil has been rubbed, can be used to imprinting invisible marks on blank forms for bills, checks, etc. These marks can be made visible by rubbing the paper with a metal stylus. Austrian patent No 12999, by the same inventor, protects the use of barium sulfate alone or in combination with zinc oxide, for the same purpose, and furthermore recommends the addition of vaseline or neutral mineral oil so that the varnish will soak into the paper and more or less expose the pigments on the surface, thus prolonging the capacity of the paper to be written on with the metal stylus. See also French patent No 757540 described elsewhere.

Inks used to safeguard negotiables against forgery -- the check-printing inks, also called sensitive or reacting inks -- can be made in the greatest variety of ways. Theoretically, one

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can use all the chemicals employed in making safety paper. The latter were mentioned in the chapter on content forgery-proofing. As the documents should also be protected against counterfeiting, all inks used for stock certificates, bonds, etc, can also be used in combination with the chemically sensitive inks. One of the oldest processes of this kind is described in detail in Ande's Papierspezialitaeten [Special Papers] page 78. Nor are we limited to actual colors. Colorless chemicals such as benzidine sulfate, manganese sulfate, guanidine derivatives, and aniline salts, and cobalt chloride, etc, may be used. In short, everything we have said about forgery indicators may appropriately be said about safety inks. Solvent indicators for instance can be produced by imprinting the paper with various hatchings in different invisible media. If when properly chosen solvents are applied, they will produce color reactions. For example, according to US patent No 1911774, check-printing inks can be produced without a binding medium, as diphenyl guanidine salts can be given a pasty, printable consistency by mixing them with water. A 60% solution of diphenylguanidine will serve the purpose. The following formula produces an ink of approximately the consistency of medium heavy printer's ink:

42 parts diphenylguanidine
20 parts glacial acetic acid
4 parts water
5 parts citric acid
30 parts triacetin
15 parts glycol

The diphenylguanidine can also be combined with other acids such as fatty acids, phthalic acids, benzoic acids, etc, in the same way. To widen the reactive range of this forgery-indicating ink, the

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addition of diphenol (see page 110 and 111) is recommended, which unites with diphenylguanidine without interfering with their individual reactions.

Another solvent indicator results when a water-soluble aniline dyestuff like rhodamine, naphthol yellow, methanil yellow, patent blue, eosin, etc, is ground in an oily or watery binding medium to make a printing ink. However, if a drying oil is used as the medium, the water-soluble dyestuffs might under certain unfavorable conditions be covered by a film of the binder which is insoluble in water, and thus be rendered more or less ineffective. Broadly speaking, the oily inks, still by far the most widely used in printing, are far more resistant to chemical and mechanical erasure than are water-based inks.

Watercolor printing -- printing with colors ground in a watery medium instead of boiled linseed oil -- deserves special attention in safety technology, and will be discussed here in somewhat more detail. Watercolors may be compounded in various ways, and we make the following practical distinction.

1. Watercolors without thickeners or binders i.e., simple water solutions of natural or artificial dyestuffs. Writing inks constitute a special case in this category. As outlined previously, using writing inks for printing has the advantage that the printing is equally sensitive to chemicals as the writing itself. This is especially true when the ink is compounded according to the 3 technically most important kinds of ink: the iron gallate, the inkwood, and the aniline. Watercolors without thickeners are usually more accessible, chemically, as their dyes have no binding medium to protect them against penetration, assuming that the dye itself

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is chemically sensitive. Aqueous solutions of dyestuffs can also be used as solvent indicators: they run and stain the surrounding paper when they come in contact with a solvent (water) or a chemical in the solvent. In this case such coal tar dyestuffs as are not easily transformed into insoluble substances -- by being varnished over, for example -- are most efficacious. Among the acid dyestuffs naphthol yellow, tartrazine scarlet, true red A V, eosin, and patent blue -- which cannot be precipitated out with barium chloride -- should be mentioned particularly. Of the alkaline dyestuffs, the various rhodamines, auramine, pure blue, should be especially mentioned, among others. Furthermore, chlorine-fast dyestuffs are useful as solvent indicators. Chloramine yellow C with suitable additions to prevent fixation of the dyestuff to the fibers of the paper, is an example. Azo yellow, chrysophenine G, and sulfocyanine G R are stable to hydrogen peroxide. The alkaline dyestuffs are especially suited for use as solvent indicators against alcohol, and often against other organic solvents as well. Ox gall, alcohol, and other detergents effect a rapid "knocking off" of such inks. Whitehead, Morris and Company, P. Morris and J. O. Bryant in British patent No 1044 (1914) suggest printing the protective background in aqueous solutions of dyes or writing ink. When the background is printed separately in different inks, these are in light-brownish shades, and only one of these consists of writing ink. In order to facilitate application of the fluid ink to the type or other printing surface, an oscillating roller made of plush or other absorbent material, inked by a special applicator, is introduced between the ink reservoir and the roller which distributes the ink to the printing surface. Glass ink reservoirs or spray devices are also envisaged, and the type or other printing

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surface may be plated with platinum to prevent alterations in the ink due to its acid reaction. British patent No 105619 (Whitehead Morris and Company and J. C. Pugh) is particularly concerned with such a device for distributing fluid writing ink on printing surfaces, and should be consulted.

Writing inks may also be used on ordinary printing presses without special inking devices if the fluid is thickened with watery media to the required consistency (compare the section on printing with water colors, below), and if the proper rollers are used.

2. Water colors with binding media or thickeners.

These can be divided according to the categories of the inks, as follows.

2a. Inks without fillers

2b. Inks with fillers.

2a. The inks without fillers are those containing no real fillers like blanc fixe, aluminum hydrate, magnesia, kaolin, etc. They are composed entirely of dyestuff solutions to which have been added binders or thickeners such as glue, blood albumin, egg white, casein, starch paste, gum arabic, tragacanth, dextrin, and other binders; or glycerine, sugar, glucose, etc. The latter 2 may be used simultaneously as solvent indicators -- for alkaline dyestuffs, for instance -- and copying inks may thus be made with them which are particularly strong solvent indicators. They also act as indicators against mechanical erasure. But they must not be made in such a way that mere friction from the hands smears the paper.

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2b. Inks with fillers. In these, actual lake dyes are ground in an aqueous binder or thickener. The pigments cannot penetrate the paper, but lie on the surface. If there is not enough binder they can easily be rubbed off, and are highly susceptible to erasure. Unlike the inks based on boiled linseed oil, they do not resist chemical eradicators. Furthermore, they are usually sensitive to water if not prepared in special ways (for instance with added hardeners, formaldehyde, chrome alum, bichromate, etc, or prepared with egg white or casein; or overprinted with oil varnish, etc) and can therefore be used in a number of ways against chemical eradicators or solvents. These inks dry to a dull finish, like watercolors, and can be produced in bright shades with very beautiful effects. Watercolor printing permits new expressive possibilities. The specimens produced by the Super-Heidelberger press and exhibited at the Leipzig Fair in 1933 by the Schnellpressenfabrik A. G. [High Speed Press Factory, Inc] of Heidelberg, appear to have excited particular admiration (see Papier-Zeitung [Paper News], No 32, 1933, page 552). Zinc line etchings, electroplated blocks, woodcuts or linoleum cuts may be used with these inks, but not half-tone plates -- because of their screen. The scoured rollers are usually lacquered to protect them from the chemical action of the inks.

If diffusing, unvarnished dyestuffs such as eosin, naphthol yellow, and others, are added to the above-mentioned watercolors, the result is a kind of a variety of double-colored ink which interferes with photographic reproduction, acts as a multiple solvent indicator, and provides further hindrances to falsification.

Fillers particularly suitable for reacting inks may be produced from a very large number of dyestuffs according to various

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processes, and only those German patents awarded specifically for this purpose are mentioned here.

German patent No 402727 (Bruno Walther, Berlin), proceeds from the frequently-mentioned theory of using writing ink as the base and adapting it suitably to use as a printing ink. When handwriting in ink on a document is attacked by corrosives, the shading or hatching beneath it, printed in a mixture based on writing ink, naturally is attacked too. Ordinary linseed oil or an aqueous binder such as glycerin can serve as a binder in the fabrication of such printing inks. Either process results in inks which, after printing and some little seasoning, are resistant to water but sensitive to ink eradicators. But the ink with the oily base is more resistant to reagents. If iron gallate is used as the dye base of the writing ink, alkalis will liberate iron hydroxyde from it, and the color will change to light brown. Acids, on the other hand, destroy the iron gallate.

The following is a sample formula for oily printing ink. Ten kilograms of tannin are dissolved in 100 l of water and precipitated with a solution of 10 kg ferric chloride (1.48 specific gravity) in 50 l of water. The blue-black precipitate is filtered, dried, and ground with an oil to the consistency of a printing ink.

For aqueous printing ink, dissolve 1,650 kg tannin, and 0.150 kg of ink blue, in 95 kg of glycerin (28^{o} Be); and 1.800 kg ferric chloride and 0.120 kg oxalic acid dissolved in 5 l water added. Gum arabic or the like is used as thickener.

The theories underlying the production of inkwood ink and the aniline inks may -- in fact, should -- be used, as these different inks react differently to reagents.

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German patent No 433176 (I. G. Farben Company, Frankfurt on the Main -- doctor H. Koecher, inventor) covers safety inks for negotiable papers, which react to attempted forgery, i.e., to attempts at eradicating the inks, with an irreversible color change. The advantage of this process over those using dyestuffs which produce color reactions to acids, alkalies, or hypochlorites is claimed to be the irreversibility of its color reaction. (However, dyes producing such irreversible color changes have long been known in the trade. For example, ultramarine turns colorless with acids, and its color cannot be restored with other chemicals.)

The process consists in adding to the paper stock, or using as printing inks, a mixture of iron or copper lakes of tar dyestuffs with ferrous or ferric cyanides or sulfocyanate salts. Moisture alone cannot affect such a color. But if acids are allowed to react with it, Prussian blue, Turnbull blue, iron sulfocyanate, or copper sulfocyanate is produced, depending on the compound used. The combination using potassium ferrocyanide is said to be particularly suited for printing purposes because of its soft consistency.

The patent furthermore claims the following advantages.

a. It is simpler than the usual processes, in that there are fewer reactive components.

b. In the case of the iron lakes, for example, the reaction with Javelle water first liberates iron hydroxide, which as an oxygen carrier acts to accelerate the oxidation of the dyestuff.

c. The iron and copper lakes of the tar dyestuffs have strong, rather dirty color tones, which are valuable in printing negotiable papers.

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d. The light-fastness of the iron and copper lakes of the tar dyestuffs is higher in general than that of the usual barium and calcium lakes.

Sample formula: 2 parts of the iron chloride lake of Paper Yellow D are ground dry with 1 part potassium ferrocyanide, and worked into the consistency of ink with a suitable oil.

It is clear that many other dyestuffs may be used in the same way, insofar as they form copper or iron lakes. In this category belong first of all the acids and the dyestuffs which absorb and penetrate directly, such as Ponceau, acid green, tartrazine, quinoline yellow, alkali blue, and many others.

Next to the graphic processes and inks, the designs chosen play an important part in protection for, in combination with suitable colors and graphic processes, they impede or make impossible imitation by hand, by photomechanical means, or by reprinting or anastatic printing, etc. They afford the greatest possible protection against counterfeiting and forgery.

The finer the drawing the more security it offers against hand-copying. In order to prevent copying by the usual technical methods of reproduction, the background of the paper used to be toned or papers strewn with colored fibers were used. In the latter case yellow fibers were usually chosen to interfere with photographic reproduction. After the perfecting of color photography, other procedures were suggested, some of them including the use of special writing inks or dyes with special safety features. These have been discussed above. Again, other processes are based upon the production of safety background patterns with continuous gradations

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of color tones or shadings, capable of yielding a very wide range of tonal variations. Successive half-tone reproductions of safety background patterns are worked out in different colors, using coarser and finer screens at various angles and at different exposures which, with the superposed impressions and choice of colors, defy any sort of subsequent analysis. But because of the great progress of color reproduction, it may become possible to achieve a perfect reproduction with a half-tone or similar process, despite the impossibility of breaking down a picture into its elements. Unless specific precautions are taken, it will also be possible to neutralize, isolate, and reproduce separately any particular color of the background or any other part of the document, or even to extract all or specifically selected colors simultaneously from a multicolored print, so that the drawing or other representation can be lifted from the document photographically or by contact printing.

The guilloches provide some of the most important safety designs. According to the definition used by the admission office of the Berlin Stock Exchange, these are delicate interlaced networks of lines which follow specific geometric laws to form various shapes. The guilloches must present technically perfect, mechanically formed shapes engraved in waves, arcs, and circles. Drawings by hand are never to be considered guilloches.

The Berlin Stock Exchange has no regulations concerning the production of guilloches. But according to a publication on the subject in the Papierzeitung, 1930, page 2700, photo guilloches lack the clear, uniform lines -- so necessary in lottery tickets and tax stamps -- which are the distinctive mark of work produced

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with the guilloche machine. Furthermore, the photoguilloche lines were frequently broken, a fact which appreciably increases the possibilities of falsification.

Guilloches or rosettes may also be made with the pantograph, a so-called reproduction attachment, or with a repetition device. These are extremely precise apparatus which operate with a tolerance of 1/50 mm, and permit the production of a particular "Schnoerkel," i.e., a twisted, interlaced scroll, loop, or flourish of any desired form and preferably repeated in regular alignment, whereby a rosette, guilloche, or border is formed. (Further details on how it is done will be found in O. Krueger, Die Lithographischen Verfahren und der Offsetdruck [Lithographic Processes and Offset Reproduction] and other technical works on the graphic processes.

Analyzing the guilloches, or discovering the line of the particular "Schnoerkel" on which it is based, is considered extremely difficult. It would be even more difficult to copy it exactly by hand. But there have been many cases in which forgers with a guilloche machine at their disposal have copied such patterns so exactly that identification of the forgery was extremely difficult. A fundamental drawback of guilloches and similar linear safety constructions is that the differentiation between genuine and spurious examples requires a certain expert knowledge and skill, and this investigation is frequently neglected. As a result, a quite superficially imitated guilloche can often be very dangerous.

In the case of an ordinary guilloche drawing, made in the usual way with a pantograph or a guilloche machine, working from a specific "Schnoerkel," the individual lines of the original loop -- and therefore of the whole figure -- will be of uniform thickness

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except at crossing points. This is due to the purely mechanical functioning or the uniform thickness of the drawing needle of the pantograph or other machine. This facilitates imitation of the guilloches.

According to US patent No 1457805 (D. E. Woodhull, American Bank Note Company, New York), certain portions of certain lines of a guilloche are therefore thickened. Thus, mechanical reproduction by mechanical means, with a pantograph, etc, is rendered impossible.

To the same end, certain areas in a rosette are excised and replaced by a different kind of drawing, such as a fine cross-hatching, etc.

In order to interfere with photomechanical copying at the same time, the array of loops in a rosette are printed in different colors, preferably chosen so as to produce color mixtures, with the color of one loop printed on top of that of another in order to maintain perfect register, especially at the crossings, as well as continuity. Further figures may additionally be inscribed in the rosettes to permit easy testing of its genuineness. A rosette produced with individually thickened lines can be exceedingly easily distinguished from one with mechanically produced lines. If a forger erases part of such a rosette mechanically, parts of it are destroyed. Reproducing it is scarcely imaginable in the case of a rosette as complicated as that in US patent No 1457805. The patent does not explain, however, how these rosettes with individually thickened lines are produced.

This is explained in British patent No 201307 (R. W. Barker, American Bank Note Company). The plate is prepared by first making

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a photographic enlargement of an ordinary guilloche made mechanically on a pantograph or guilloche machine. On the enlarged reproduction, of which Figure 14 shows a detail, certain areas are now accentuated by hand (b Figure 15) or hatched (c Figure 15). The modified drawing is then reduced photographically to its original size. This reduced drawing is reproduced on the plate by a photo etching process. Guilloches with accentuated line-areas can also be produced more easily on the photo guilloche machine.

Individual lines can be eliminated from the enlargement by covering them with ink before the color plates are made. For example, the picture can be divided into 4 parts if it is to be printed in 4 colors. Or any guilloche can be printed by partial inkings of the plate, so that several colors can be printed at once, and not superimposed (sectional inking). This is explained as applied to the offset process in the inclusive British patents Nos 200294 and 237695 (R. W. Baker, American Bank Note Company), which cannot be discussed in detail at this point.

In this connection we must mention the synchronous color printing process, which is used particularly in the intaglio processes. All the colors are applied to the plate by means of ink balls or dabbers, and the colored print results from a single impression. Of course perfect register is also achieved in this way.

Proper photographic techniques, especially the bromide collodion process, make it possible to produce photographically reduced guilloches which display sufficiently well-defined lineation, so that, if properly executed, they ought to meet the requirements of the Berlin Stock Exchange.

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Another way to produce printed safety patterns that are difficult to imitate is adduced in British patent 1136 (1914) (Whitehead, Morris and Company, and E. H. Farmer). It combines a half-tone picture with a special safety configuration (guilloches, rosettes, etc) in such a way that the separate elements remain recognizable. This pattern may be protected by other safety measures against photographic copying, reprinting, or contact copying (as in British patent No 29491 (1912).

To make a plate for high speed heliogravure, for instance, the plate is first covered with a light-sensitive layer of fish glue which is resistant to acids. A guilloche, etc, is copied on this layer and developed. Thereupon a wash drawing is applied and developed in the pigment or carbon process. The surface of the plate is then etched through the 2 acid-resistant layers. Drawings can also be copied directly on the same pigment or carbon-paper in the familiar carbon process. Special effects are possible by making modifications in the etches. Plates in relief are produced by copying negatives. Furthermore, the plate may be weakly etched and an impression taken in one color, then etched deeper and an impression made in another color, etc.

In addition to guilloches, other drawings with extremely intricate lineation, such as relief backgrounds, are used in safety paper printing. Such printed pictures with 3-dimensional effect, as well as printing cuts in relief, are produced according to various methods and processes. See Albert's Lexikon der graph. Techniken pages 190-191. Artistic representations of character heads, in shaded drawings, have also been used. But all these complicated drawings can be imitated by skilled draftsmen or reproduction technicians.

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To make it impossible, or almost impossible, to copy drawings by hand, confusion screens have been used which alter the dot pattern of the details of the drawing or of the screen. They also alter the points on the printing plate and thus of the dots on the printed impression. As a result it is extremely difficult to imitate the latter by hand. Thus, according to Austrian patent No 85401 (Engineer K. Hazura and J. Aufreiter, Vienna) a photographic negative (or positive) is made from an original which is in one gray value or several gray values from white to black. This is done through a screen totally or partially composed of parallel or nearly parallel curves (which do not intersect). In the negative, the transparent lines are thicker in the shadows and thinner in the lights of the original. In the positive the lines are thicker in the lights and thinner in the shadows. The original in this process is not reproduced by dots, but by lines, which are so arranged that imitation by hand is made significantly more difficult. Now if such a photographic negative or positive is used in the preparation of a printing plate by one of the usual photomechanical processes and impressed, directly or indirectly, on paper with ink or some other medium, an impression results with a pattern corresponding to that on the original, with parallel or almost parallel lines which do not intersect each other, and with the lines becoming thicker or thinner on the areas of the reproduction which correspond to shadows and lights, respectively, on the original.

Documents produced partially or in their totality by this process cause the forger greater difficulties in copying than is involved in copying documents produced in the usual way, with ordinary guilloches.

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The use of confusion screens is likewise suited to the task of making it extraordinarily difficult or impossible to make color plates photographically. In the familiar autotype [photo-engraving] processes, which use various kinds of screens and shutters, the original is divided into round or angular points, or dots, depending on the kind of shutter used, and the dots are larger or smaller depending on the tonal values of the original. For the preexposure only shutters with round holes are used, for the picture exposure found or square apertures can be used. For special effects slotted shutters are used. Slotted shutters combined with screens made up of crossed lines produce sharp straight lines but do not reproduce the effect of the original.

In German patent No 439376 Orell Fuessli Art Press, Zurich the original is divided into lines thickened or thinned according to the lights and darks. Reproducing all the tonal values of the original, the process includes a unique combination of a slotted shutter and a line screen.

In this process several exposures are made for each photograph. The duration of each exposure, as well as the width -- and in certain cases even the length -- of the shutter aperture, can be regulated depending on the nature of the original and the degree of reduction involved. This makes it possible to subdue or accentuate tonal values.

Shutters with apertures of various shapes may yield lines that appear twisted like ropes, or smooth continuous lines that taper and swell and are useful for bank notes.

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The great advantage of this process lies in the fact that, instead of a screen with a pattern of smooth lines or waves, a screen with modelling, tonal effects, and a pattern of its own can be produced, and in a fashion that makes it virtually impossible to abstract photographically the individual color plates from the finished bank note. In addition it is obvious that 2 or 3 plates prepared by this process can be printed on top of one another. This adds a further difficulty to imitation, both in the isolation and photography of the separate colors, and in the reconstruction of the individual color plates.

The process for protection of valuable papers against photocopying in German patent No 320596 (Whitehead, Morris and Company, Ltd., and E. H. Farmer, London) is based on the following principle.

When a smooth surface is coated with metallic ink of high reflectance, it is difficult to make a uniform photographic reproduction of the surface because the incident light from certain angles must be blocked off while, actually, it should be distributed evenly and simultaneously from all angles. But if the surface to which the metallic ink has been applied has a grainy or undulating appearance, a photograph will obviously reproduce these mechanical irregularities.

Now if 2 colored shapes -- one red and one green, for example -- with sharply defined outlines, are printed on this surface at distances of a fraction of a millimeter from each other, the surface will appear to be covered by the colored shapes and the metallic surface will be hidden. But in a photograph of these sharply defined, closely adjacent shapes the extremely thin line of the metallic surface will be decidedly visible because

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centers [points, foci] of reflection will be formed which will overlap the colored shapes. Thus the outlines of the color shapes will become blurred, and in the case of complicated designs, with thin lines, etc, the latter will be distorted and the design will be completely altered.

According to the invention, the background is treated with gold, silver, lead, or other materials or alloys with a high coefficient of reflection so as to produce not only a glossy, glazed surface but an irregular, uneven surface that diffuses light markedly.

The gold or other materials may be imprinted on the stock or incorporated in it. Practically, it is preferable that the surfaces reflect and absorb the light differently at every point. This can be accomplished in the following ways:

(a) by using a background with irregular grain or an open weave; the paper having been impressed with a network matrix under heavy pressure in order to attain light diffusion at a multitude of points (goffering);

(b) by impressing the background with a printing surface equipped with points, so that the printed surface under the magnifying glass appears pricked, with individual points or areas of the background here and there left unprinted or printed differently;

(c) by burnishing the background in different ways, so that the light is diffused differently by different parts.

The practical value of this process lies in the fact that in any attempt to reproduce the bank note photographically, either with a camera or by means of contact printing, the background

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treated in this manner will so diffuse the light that halation, light spots, and aberration errors are produced to such an extent that, as far as bank note designs are concerned, no negative usable for counterfeiting can be made.

It is to be noted that the invention is applicable not only to bank note paper but also to such other valuable documents as are made of silk, linen, or other weaves and are saturated or imprinted with gold, silver, or some other shiny metal.

As concerns the metals, it should be noted that silver and lead are dulled with relative ease, for example, by treating them with hydrogen sulfide gas. Thus they are browned or blackened, whereupon photographic isolation, at least from decidedly different colors, would be possible. More suitable would be a so-called tin-foil, produced, for example, with a coating of tin and subsequent friction, as most producers of colored papers produce them.

Unlike lead paper, such a paper is not poisonous and is considerably cheaper than paper made with real silver or gold.

But the comment must be made, with respect to this process, that a skilled reproduction photographer will have no great difficulties in eliminating the deleterious effects of metallic reflections on his negative.

Another process is described in Austrian patent No 82238 by the same inventor. It concerns the fabrication of negotiable papers which are protected against photographic reproduction, contact printing, and reprinting. The process is based upon the following basic principles. When cloth is woven from thread, or

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when a large number of lines -- geometric or other -- or sharply outlined forms, or designs (hereinafter referred to as elements) is produced on the surface of a sheet of paper or other material, the total impression to the eye depends on the size of the elements, their color, their distance from one another, and their shape. The resulting effect will be one of the following.

(1) If the threads or elements are large enough and distant enough from each other, the eye will be able to distinguish exactly every detail -- the shape, color, and position -- and the effect will be that of a pattern.

(2) If the elements are small enough and close enough together, they will appear to the naked eye as a tone or a shading, as the various elements merge or fuse together and the eye is incapable of analyzing, individuating, or distinguishing the individual elements either as regards their shape or their color.

(3) If, however, the size and separating distance fall somewhere between the first and second sets of conditions, not too far apart and easily distinguished by the eye, the impression will be that of a texture, the characteristic overall appearance of which will depend on the size, position, shape, and color of the various elements. Specific examples of such textures are the above-mentioned textiles, as well as the various forms of screen patterns used in color photography, which by their fineness determine whether a texture, a pattern, or a toned surface is produced. White and black are regarded as special colors in this connection.

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A given combination of elements, for example a row of closely juxtaposed, differently colored hexagons will appear as either a pattern, a texture, or a tone depending on the size of the individual color elements, which, for example, could be red, green or blue, or red, yellow, and blue, or some other combination.

In the case of configurations which fall under (2) or (3) above, i.e., when the elements consist of sufficiently fine or broken lines of different colors, or are sharply angular or otherwise sharply outlined colored shapes, they can be reproduced only very incompletely by photographic means. This is because of the refraction of the light passing through the camera lens and other aberrations and errors in the various steps of the photographic and reproduction processes.

If, therefore, there is a texture in the present sense in or upon the body, stock, or ground material of a check, etc, and if the individual elements thereof fit together exactly, so that the total configuration of these elements substantially or completely covers the surface to be protected, then the result is a safeguard against reproduction by means of the photographic camera.

Though the possibility of reproduction by means of the photographic camera may thereby be restricted, there is actually no such limitation to the possibilities of reproduction by contact printing. Hence, if the above-mentioned texture is supplemented by or incorporated with a background consisting of lines, dots, designs, etc, whose elements are sufficiently opaque (i.e., sufficiently nontranslucent) when combined with the printed designs of the document and if in the use of colors for the base contrasting

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colors other than black and white are chosen and used, so that the photographic effect of the 3 basic colors cannot be suppressed or simultaneously rendered ineffective either through combinations of color filters, colored light, and color-sensitive photographic plates, then, in case there is an attempt to isolate or extract the drawings or other parts of the document by means of contact printing, there will always be enough background which cannot be rendered photographically ineffective. This background will make it impossible to achieve satisfactory or completely successful results by means of contact printing.

It also provides protection against counterfeiting by means of transfer reprinting provided it is prepared in such a way that it transfers along with the design, so that the transferred design cannot be reproduced because of the background which was transferred along with it.

In accordance with the patent under discussion, then, a texture, or net-like or web-like configuration is produced in or upon the base of the check, etc, composed of elements which in size, color, and shape answer the above-mentioned requirements for a texture, and which completely, or almost completely, covers the surface to be protected. Depending on its composition, the texture exhibits a characteristic appearance which depends primarily on the size, shape, and color of its individual elements, and secondarily upon their grouping.

The characteristic texture may lie in the base of the check, etc, itself, or it may consist of elements imprinted on the surface, in which case the texture may cover all or only a portion of the check. In case the texture is produced by one of the graphic

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processes, it will in practice be composed of sharply contrasting colors, but not black and white, nor in one color and white. If the texture is produced as a weave, it may be also made in black and white, or one color and white, or in an other selected single color, without making it possible to reproduce it by means of the camera, as the black and white elements can be made too fine for the camera and still be recognizable as a texture.

A characteristic texture can be formed in the substance of a bank note by suitably chosen textiles, the threads of which are pulled and so aligned as to give the impression of a texture, rather like the damask patterns often woven into, fine cloth or silks. The material will preferably be thin enough, translucent, or open-meshed, so that after treatment with suitable dressing tools it will have the same strength and stiffness as the usual paper. At the same time single or multiple imprints will be partially visible from both sides of the note. The textile may also contain information, or the designation of the note, and the denomination of the note might be woven into it.

In case the texture is applied to the surface of the note by one of the graphic processes, various familiar processes may be employed. The following examples may serve.

(a) The design for such a composite texture may be drawn up on an enlarged scale and the printing plates for the various elements may be reduced to the desired small scale by gradual photographic reduction.

(b) The pattern which forms one component of a texture, for instance one of those obtained by photographic reduction from a

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texture drawn at a large scale, may be imprinted by means of a single plate at 2 or more points, one after the other, and the successive impressions may be made in different colors.

(c) The various components or elements of the composite texture may be engraved or etched directly into the engraving plate.

(d) Various reproduced elements may be obtained by successive or simultaneous impressions in different colors from the lower and higher portions of the same plate.

(e) The 3 colors of a texture composed of 3 distinct colors may be produced in one impression: one of the colors by means of the hollowed-out portions of the plate, the second color by the raised portions of the plate, and the third color by interposing a thin, open-meshed textile, netting, or stencil, the lower surface of which serves to print the third color while the first and second colors are being printed through the holes. The third color may also be obtained simply by masking and coloring the paper with the mesh, netting, or stencil, instead of being printed with it.

(f) The plates may be reetched or reengraved in order to make changes in the product between successive impressions.

(g) Separate plates may be made from a negative, positive, or original in such a way that they correspond exactly, for all practical purposes. For example, the fact that a negative and a positive are exact opposites, and that the transparent areas of one of them fit perfectly with the opaque areas of the other, may be used for the preparation of plates with which a set of small, exactly fitting surfaces may be reproduced.

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Insofar as the characteristic effect of a texture is produced by the exact fitting together of the individual elements, and as these elements themselves are extremely small, it will be evident that even the most trivial error at the edges where the elements are supposed to fit together will produce a typical blurred effect which is different from the original texture, and which makes any attempted counterfeit immediately recognizable and obvious. Furthermore, according to the invention under discussion, a background composed of lines, points, or other patterns or designs may be provided in combination with the texture or in addition to it. This background may be produced in the material of the paper or on the surface by processes identical or similar to those used for the production of the texture itself. When this background is executed in colors other than black and white, the colors must be chosen not only in such a way that the photographic effect of the elements forming the background cannot be entirely and simultaneously suppressed or nullified but also so that, in combination with the design, etc, on the note, these elements are also sufficiently opaque so that the design will be damaged or distorted if reproduction by means of contact printing is attempted.

When the above-mentioned texture is formed in the material of the paper itself, it may contain or fulfill the function of the effect of the background as a result of the depth and, consequently, the opacity of its color elements.

When the texture or the overall network effect is produced by one of the graphic processes, it may incorporate the elements of the background, which then will appear as part of the texture. In this case the texture itself becomes a safeguard against

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counterfeiting by contact or transfer processes. If, for example, a fine line system or a similar configuration is repeated in close juxtaposition in 3 colors, it will result in a tone determined by the fineness of the impression. Now, if a fourth color is applied at a slightly different angle, the effect of a texture will be achieved, and if the dimensions of the elements are small enough, and the colors suitably chosen with regard also to their opacity (or the opacity of one of them), this texture will constitute a background.

It is clear that a complicated line network or a bank note pattern such as those ordinarily used is to be preferred, and in practice will be used in combination with the characteristic note surface produced according to the invention under discussion. Such a pattern may be superimposed over the composite background. Furthermore, if the texture is being produced with the background in successive impressions, or if the background is being made in this manner, the bank note pattern or design may be made in one of the intermediate impressions; and in this or any other manner may be interlaced with the counterfeit-proofing elements of the texture and background or of the latter alone.

As we mentioned earlier, the matter which forms the safeguard against counterfeiting need not cover the entire surface of the note, and its elements may for instance be printed in such a way that they themselves constitute portions of the text or of the ornamental decoration of the note.

One graphic procedure which is rather widely used in providing protection against counterfeiting is based on the unlikelihood

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of its being discovered. It consists in making some identifying mark on a plate -- perhaps in a sentence of a stock certificate -- before impressions are made. The plate is ready to be printed, and an official of the firm for which the shares are being reproduced removes a part of a character -- perhaps the dot over an i -- or damages some other letter. Of course there must be no witnesses, and the plate must be destroyed immediately after the printing is finished -- a demand frequently made of printers. Such minor deformations of letters generally escape the attention of counterfeiters, who frequently fall into these quite simple traps. But in case of a photographic reproduction such a safety measure is useless. Besides, to be effective, it depends on strict secrecy.

The so-called cross-hatching represents a printed pattern which is commonly used to protect checks against mechanical and chemical erasure.

This is not merely a matter of narrow, straight, parallel line patterns. Many others forms have been developed. For example in the year 1909 the firm of George La Monte and Son registered a trade mark with the US Patent Office. It consists of a background in the paper formed by parallel, closely placed, wavy, horizontal lines. They are uniformly distributed over the entire surface of the paper and offer a general safeguard against mechanical erasure. The Orell-Fuessli firm in Zurich (Switzerland) subsequently used a similar background imprint for its safety papers, and a lawsuit consequently arose between the 2 firms which was settled before the Swiss Federal Court in Lausanne in 1929. These legal determinations are of special interest for printers of safety papers, as they draw clear boundaries between the protection of trade marks and

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that of inventions in this special field. Trade mark protection extends only to the designation of commodities, and does not cover designations in which a specific technical result (such as the prevention of erasures) is achieved. Only patents apply to the latter.

But, if simply executed, this kind of hatching and background impression may be easily corrected [if damaged by erasure] and generally withstands chemical erasures if the inks are not suitably compounded. At the same time, the inks should be chosen so as to make photographic reproduction more difficult.

While the above-mentioned patterns serve primarily for protection against counterfeiting and forgery, more or less simple patterns or letter arrangements have been invented especially to give warning if forgery has been committed.

US patent No 1431903 (G. Becker, Scranton) proposes first to imprint check or document-paper with a symbol -- namely, the word void -- in very thin letters, with a resistant ink. Superimposed, or next to it, a second, compatible pattern, in a nonresistant ink such as watercolor, writing ink, etching ink, etc, is imprinted in such a way that the first pattern is hardly legible. (See Figure 16). If such a paper is treated with corrosives, the pattern printed in the sensitive ink will disappear, and the word void will appear prominently (see Figure 17). The first symbol, the word void, may also contain, or have printed parallel to it, forgery indicators which darken readily with ink eradicators. In this case the word void would stand out more prominently after being treated with ink eradicator. The color tones chosen are preferably light, so that ink writing on the document will be easily legible.

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Similarly, according to US patent No 1454837 (B. W. Smith, Todd Protectograph Company, Rochester), a safety paper is imprinted with an ink that cannot be erased mechanically or chemically. It is masked by a superimposed imprint of the same shade, but in ink that can be erased and eradicated. Now if an area on the document is treated with chemical ink eradicators, the first, ineradicable imprint appears. It serves to destroy the validity of the document. For example, the word void (in German: nichtig, ungueltig) in ineradicable ink and in small letters (Figure 18) appears over the entire surface of the paper. Superimposed, but with letters at a different angle, is the word void again, in eradicable ink. Thus a configuration is formed (B, Figure 18) in which the word void is hidden and unnoticed. But if the paper is treated with bleaches, the ineradicable imprint, reading void, becomes prominent (A, Figure 18), and thus warns the receiver. The second ink -- the one which can be eradicated or erased -- is preferably chosen in such a way that it is sensitive to chemical as well as mechanical erasure. It may also be composed of a watermark, or of an ink that is darkened by corrosives.

The ineradicable ink may be composed of carbon black ground in a hard-drying oil medium, for example. The nonresistant ink would then consist of a black eosine lake ground in a gum arabic solution with a little glycerine.

Depending on the characters used, the restoration of eradicated characters or of a single bleached stroke can be accomplished more or less easily, so long as no other forgery indicators are added and no paper that is completely impregnated with forgery indicators is used.

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This is less true of the safety paper in US patent No 1578908 (J. W. Neff, Easton), which is impregnated or imprinted with aniline salt or other colorless forgery indicators (Figure 19). When brought into contact with ink oxidizers, the imprint (for example the words void or canceled) and the paper are darkened (Figure 20); the aniline black which is formed can only be removed with boiling sulfuric acid. This, however, would destroy the paper. In order to render the aniline salt more stable to atmospheric conditions, it is somewhat acidified. According to US patent No 1652042 of the same inventor, lactic acid, citric, stearic, etc, may be used. According to the latter patent, the paper completely impregnated with aniline salt is imprinted with aniline salt while wet (Figure 21.) By this means the aniline salt is supposed to be deposited more densely on the printed areas, so that the difference between the discoloration of the paper and that of the imprint, when an ink oxidizer is applied (Figure 22), will be more pronounced. To make this paper sensitive also to mechanical erasure, another colored, sensitive coating is provided. This process has the advantage over the preceding method that single-stroke bleaching is made more difficult. (But the aniline salts are not stable enough in air.) The advantage of protection against forgery by bleaching out individual strokes may of course also be obtained by overprinting a paper containing a forgery indicator with more forgery indicators.

In the following process, based on US patent No 1817171 (B. W. Smith, Todd Company, Rochester), which provides a good safeguard against single-stroke bleaching, the use of such a safety paper is unnecessary. In this process the repeated word void is printed

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over the entire surface of the paper. The individual words are closely juxtaposed and preferably in colorless ink, but in negative form, with the areas between the letters receiving the ink while the letters themselves do not (Figures 23 and 24). Furthermore, the letters are composed of interrupted elements -- dots, for example. This results in the advantage that the warning signal is much more difficult to see than in the processes mentioned above, as the eye is not accustomed to reading negative impressions. Even if the paper is viewed at various angles to the light, an impression of this kind is hardly perceptible, if at all. As inks, colorless forgery indicators like manganese ferrocyanide, tolidine hydrochloride, benzidine sulfate in oily or watery binder (glycerine and gum arabic) are suggested -- to which zinc white and other primers may be added. But if the printing substance does not penetrate more deeply into the paper it is possible to scrape it off before chemical or mechanical erasure. Therefore the reactive layer is effectively covered with an erasure-proof imprint. The same inventor recommends the ink made according to US patent No 1911774 (see page 86) for the same purpose.

The process covered in US patent No 1588201 (B. W. Smith, The Todd Company, Inc., Rochester), aims at the production of a safety paper which is protected against mechanical and chemical erasure, which superficially looks like a good quality writing paper -- a ribbed (or laid) paper, such as that made on the paper machine with special rollers or wire meshes. This is achieved by imprinting the paper with fine straight or other lines with an ink sensitive to chemical forgery. The color of the ink is only slightly darker than that of the paper, so that the same effect

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appears as in a watermark or printed watermark. The ink, for example, consists of manganese ferrocyanide, tolidine hydrochloride, benzidine sulfate, or the like, ground in an oily or other binder. The ink can also be prepared in such a way that it is sensitive to mechanical erasure.

If ink eradicator is applied to such paper, dark lines or spots appear on the affected areas, giving the impression, for instance, that these areas have been cancelled to render the document void.

The value of such a paper depends primarily on the character of the corrosion indicator used and on the additional forgery indicators and identifying features used in combination with it.

A further, more effective safeguard against chemical and mechanical erasure can be obtained by combining concealed warning signals with guilloches or similar forms.

The protection value of a guilloche lies especially in the difficulty of analyzing it, and in the difficulty of repairing it once an erasure has been made. US patent No 1675769 (B. W. Smith, Todd Company, Inc., Rochester) aims at the same effects combined with warning signals. Here 2 or more patterns are imprinted over one another on a safety paper. One of these patterns consists of a great number of little dabs or spots, very close together, between which a different color is applied. The second, which is superimposed on the first, is so combined with the first that a blurred, confused overall pattern results. The ink is sensitive to ink eradicators, so that after any attempted chemical erasure the individual elements cannot be restored. While the separate patterns each have a regular, easily decipherable geometrical

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design -- for example, a regular hexagon (Figure 25), octagon (Figure 26), etc (with corners and center represented by circles, etc) -- superimposition of the 2 produces a complex pattern (Figure 27) which can only be analyzed into its component patterns with great difficulty. Maintenance of register is by no means required, a fact which greatly facilitates the work of the pressman. The word void or some other warning signal may be imprinted in resistant ink over the complex pattern or in its elements -- perhaps inside the little circles, so that it is scarcely perceptible but emerges prominently upon any attempt at applying bleach. This process may also be combined with that of US patent No 1454837, of the same inventor, which increases the protection value of the latter.

This process is supposed to render the restoration or imitation, or individual elements more difficult than with a pattern composed of individual strokes or designs, such as rosettes or borders.

An improvement of the process just described is described in US patent No 1689302 by the same inventor. In it the warning symbol void, for example, is printed in an ink consisting of colorless forgery indicators (manganese ferrocyanide, tolidine hydrochloride, benzidine sulfate, etc) while the basic patterns for the confusion pattern are printed in inks which resist eradication. If mechanical erasure is attempted on such a safety paper it is practically impossible to restore the damaged portion of the pattern. Attempts at chemical corrosion result in the appearance and easy legibility of the word void, in black or dark color, and the receiver is warned. However, the forgery indicators named would not alone suffice but would have to be reinforced by others.

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The primary advantage of this process, practically speaking, lies in the fact that the entire paper has the light, fast dyes desirable in permanent documents, making handwriting easier to read than if darker, stronger inks were used (as required in US patent No 1675769).

To prevent not only mechanical or chemical erasure but also the easiest kind of forgery -- additive forgery or fraudulent additions such as check "kiting" -- the imprinting of indications of maximum value on checks and letters of credit has been suggested. This procedure, properly carried out, gives excellent protection against this type of content forgery. Each value entry is written in 2 different ways. The first time in the normal fashion, with ink, and a second time by canceling certain numerals from a line of figures in such a way that the uncanceled numerals equal or come as close as possible to the desired value designation.

A similar procedure used to be required in Germany. The maker of a check used to be required to detach or cancel the numbers superior to the nominal value of the check from the row of numerals located at the right hand side of the blank. Fraud was still possible, within limits, as the blank form was not efficient enough. The already widely adopted standard check, which had meanwhile been proposed by the Committee for Economic Management of the Reich Economic Board at Berlin in the light of recommendations made by the Berlin Society of Banks and Bankers, no longer incorporated this safety feature.

According to US patent No 1286346 (D. C. Davis, Wilkinsburg) maximum values are printed on check forms, etc. The paper is then cut or perforated either under, over, or adjacent to the maximum value indications, or the paper is desized in these areas by

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chemical or other means. Either way, the purpose is to make the paper ink-absorbent in the vicinity of the printed maximum values. When the check is written, all the inapplicable maximums are cancelled in ink. The ink soaks deep into the cut or desized areas, making mechanical erasure impossible and chemical erasure exceedingly difficult, provided the proper chemicals are used. But excess ink used in cancellation might soak all the way through and inadvertently cancel the values on the next blank in the checkbook. To avoid this, the cut or perforated areas on successive blanks are located alternately above and below the value indications.

According to US patent No 1799499 (R. E. Bohrer, Rochester, US, The Todd Company, Inc., Rochester), the maximum value designations are applied to the paper invisibly or unnoticeably. These invisible numerals can easily be transformed by the initiate into visible, exceedingly fast, ineradicable numerals. The aim of this process is to prevent or indicate fraud by chemical or mechanical alteration of the numbers or by "kiting" its intended value.

The maximum values may be applied as watermarks -- but these would be visible by transmitted light -- or in colorless, invisible ink which becomes colored and fast when treated with ink eradicator. The position of the maximum value symbols may be entered by mechanical means; for instance, by using a stencil supplied with the check book, a very practical procedure. The process also provides for a combination of the maximum value imprint with that of warning symbols (such as the word void). The latter also are printed in sensitive invisible ink according to one of the processes already mentioned.

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Chapter VII. Safe Writing Techniques

Writing safeguards afford protection against both counterfeiting and forgery. Several protective techniques have already been mentioned in the preceding chapters, such as the use of chemicals with identifying features or detergent ink additives.

The surprising ease with which ordinary commercial inks can be removed from paper is responsible for most forgeries, and it is no wonder that many attempts have been made to develop an indelible ink. (For the behavior of inks with chemicals see A. Robertson and J. J. Hofmann, Pharm., Central-Halle, 1892 and E. Locard, Traite de Criminalistique). India Ink is wrongly considered to be ineradicable. While it does not bleach out with chemical eradicators, it can be removed with soapy water, or by the process described in the chapter on forgery, or with commercial products, such as Tuto or Tuschex. Similarly, according to V. T. Bausch, Antigan ink, which is considered difficult to falsify, can be washed out with soap and water or spirits of soap, especially if the paper is highly sized.

In theory there are many ways of compounding safety inks for protection against forgery. Thus, most of the chemicals used as forgery indicators may be combined with ordinary writing inks. Instead of the amino compounds, which are difficult to dissolve, their soluble salts or sulfo-acid salts may be used. The latter often have the advantage of not precipitating ordinary ink dyes. The ink industry already manufactures similarly compounded dyes, such as the inks with which laundry is marked in such a way as to resist the effect of hypochlorites and other bleaching agents.

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Such inks are composed, for example, of hydrochloric aniline, copper vitriol, sodium chlorate, acetic acid, and a thickener (see C. Becker, Die Fabrikation der Tinten, Tuschen und Stempelfarben [The Manufacture of Inks, India Inks, and Stamp-Pad Inks], 1934, Augsburg). However, they are not entirely suitable as substitutes for ordinary writing inks because of their lack of permanency.

A great number of organic and inorganic substances may be added to ordinary commercial inks without seriously affecting their writing qualities -- for instance, the double salts of metallic oxalates, metallic complex salts, copper sulfate, manganese sulfate, silver nitrate, etc. Mere chlorine-fast or bleach-fast dyestuffs may also be added to the writing inks. (A safeguard against mechanical erasure is also produced by the addition of dyestuffs which penetrate and diffuse into the paper).

But these materials can often be eliminated from the dried ink before actual forgery is attempted. As a result their value is doubtful. Ink supplements after drying should be insoluble in all solvents and produce a practically irreversible discoloration with corrosives. These requirements -- to which good fluidity must be added -- should be capable of realization.

According to British patent No 217053 (Davidson), a safety writing ink can be prepared by adding aluminum-, chrome-, or iron-sulfate to ordinary commercial inks. However, the hydroxides, which are formed therefrom by treating them with alkali hypochlorites, are dissolved readily in acids. But as the above-mentioned salts penetrate deep into the paper, these dissolution procedures leave faint traces which may be detected by means of the dark ultraviolet light. Iron sulfate, while on the paper, gradually turns

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into the almost insoluble iron hydroxide, so that the iron vitriol cannot be washed out before an actual forgery is undertaken. But even in the ink solution it begins to liberate hydroxide, which affects the writing qualities of the ink if the separation is not inhibited by strong acids which attack steel pens. Iron sulfate chloride behaves better in this regard, which is why it is preferred for the preparation of iron gallate ink.

According to German patent No 331622 (H. Gethe, Duesseldorf), a bleach- and oxidation-proof ink is prepared by adding prussiate of potassium to ordinary writing ink. The following formula may serve as an example:

25 g	extract of dyewood
9 g	aniline dyestuff (water soluble)
1.5 g	prussiate of potash
1.5 g	pyrogallol

plus the iron compound chosen, liquefied in 500 g cobalt sulfate water, and filtered.

The patent does not specify whether yellow or the red prussiate of potash is to be used. Perhaps either of them, or both together, would be suitable. While the ferri-salts do not precipitate with potassium ferri-cyanide (red prussiate), but yield a brown solution; ferro-salts with potassium ferro-cyanide (yellow prussiate) first produce a white precipitate which on exposure to the air oxidizes to blue (Prussian blue). Ferro-salts with potassium ferri-cyanide produce a blue precipitate (Turnbull's blue) which is soluble in oxalic acid. Properly compounded, safety inks prepared according to this process far excell ordinary writing inks in protective properties.

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Safety inks whose chemical principle resembles that of phototracing paper may also be made. And many sympathetic inks, of which a large number are described in the literature, belong in part to the safety inks.

A safety ink ought not only to be chemically ineradicable, but in addition ought to contain substances which produce characteristic effects in dark ultraviolet light, so that the fact of a chemical or mechanical attack can be detected more easily. A mechanical erasure is particularly easy to detect if these chemicals penetrate through to the reverse side of the paper.

But the best safety inks will never eliminate the use of safety papers with forgery indicators, as the latter clearly betray any attempt at chemical erasure over the whole area to which chemical ink eradicators are applied. Rather, an excellent safety paper can eliminate the need for safety ink, as no ink can be removed from it chemically -- at least not without some obvious reaction. From the standpoint of technical security, both safety paper and safety inks should be used.

Paper may be written upon not only with inks, pencils, etc, but, if properly impregnated, also with an electric current, between electrodes. Very durable writing which penetrates the paper may be produced in this way. Electrolytic writing paper is used especially for the electrical transfer of pictures. The details concerning these papers would take us beyond the scope of this book. They may in part be used directly as safety papers. We shall therefore only list the following patents. They include thermal processes in which the writing is done with a heated stylus.

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German patent 498740	Formation of minimally soluble organic metallic compounds, such as alizarine copper, nickel dimethylglyoxime, etc.
German patent 402394	Use of cadmium iodide, etc.
German patent 511164	Iodide or iodide and starch, supplemented by reducing agents to prevent separation of iodine during storage
German patent 511165	Supplement to preceding. Addition of alkali.
German patent 512381	Cadmium- and potassium iodide and other salts.
German patent 523258	Utilization of used acid fixing bath solution in which the silver may have been replaced by lead.
German patent 523653	Use of a paper covered with metal foil.
German patent 536506	Use of nitroso-barbituric acid (violuric acid) with iron electrodes.
German patent 543635	Heat-sensitive paper. Consists of gelatine, an oxidizer and an organic substance which yields a colored oxidation product in the presence of heat (aniline hydrochloride, etc.)

Incidentally, it should be noted that Goppelsroeder (Wagners Jahresbericht 1875 [Wagner's Annual Report 1875], page 9527) wrote with an electrode stylus on a fabric which had been impregnated with aniline salts.

German patent 556841	Writing on a blank with a conductive ink (Aquadag).
German patent 557064	Heat sensitive paper, made by impregnation with organic heavy metal salt (silver stearate, antranilat, lead thiobenzoic acid, etc.)

And finally, paper may ordinarily also be branded with a red-hot stylus.

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Handwriting can be safeguarded by chemical or mechanical means after the ink has been applied to the paper. Thus, in German patent No 328787 (H. Gethe, Duesseldorf), powdered potassium ferrocyanide is dusted on a written document or blank by means of a cloth bag with an open weave. Handwriting in ink already dry may also be treated in this manner; the paper should first be moistened.

Already dry handwriting may also be protected by a coating of varnish or lacquer (Zapon varnish, paraffin) or with transparent paper tape. The firm of Kalle and Company of Biebrich manufactures completely transparent cellophane tapes, which adhere without being moistened and are likewise suitable for such purposes. But protective measures of this kind do not offer adequate protection in themselves and therefore should be combined with other safeguards.

A. E. Meyer of Chicago, in US patent 1174753 seeks security against chemical or mechanical forgery of all writing and printing on the face of a check, etc, by crimping or, rather, goffering the entire document after it has been written upon. Much simpler devices suffice for this purpose, such as the check-writing machines, etc, which usually write only certain items, primarily the amounts.

But, when used alone, this procedure does not offer adequate protection, against chemical or mechanical erasure. Even without forgeries it will occur frequently in practice that certain areas of the document will accidentally be printed flat and thus give rise to suspicion. But a goffered document can also be treated chemically, for instance with bleaching agents disolved in organic solvents, without damaging the goffered paper as aqueous solutions do.

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Mechanical writing processes, for instance with the typewriter, as usually executed likewise offer insufficient protection against forgery. Typewritten characters may be erased mechanically, even though this may often be difficult. Black typewritten characters withstand chemical erasure, especially when the pigment used is composed of lamp-black, which is usually the case. Blue and violet typewriter ribbon inks, however, are easily removed with chemicals.

A safety procedure frequently used by banks consists in writing checks with carbon copies. The carbon copy (made with carbon on a special printed form, or with the Transcrit process) is sent to the drawee bank as an advice. The latter compares the original check with the carbon copy by superimposition by transmitted light to see whether they correspond exactly. But if a forger has access to a customer's check book, and at the same time knows and falsifies the written advice form, his fraudulent act will succeed that much more easily.

Excellently protected against chemical and mechanical erasure is the work produced by a typewriter with a special type face. The characters of this safety typewriter (manufactured in Germany by the Mercedes Bureaumaschinenfabriken [Mercedes Office Machine Factories] at Zella-Mehlis, and the Europa-Schreibmaschinengesellschaft [Europa Typewriter Company], Berlin) are provided with needle-pointed spurs which prick tiny holes in the paper (Figure 28). The face of the paper is inscribed in several colors at the same time by means of a multicolored typewriter ribbon, while on the reverse it receives the impression of a colored carbon paper. Falsifications by means of additions or masking are possible under certain conditions.

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Very good protective perforating writing devices are in use as check-writers.

According to US patent No 869823 (E. E. Angell, Boston) the spaces between letters, numerals, or other conventional symbols are pierced, goffered, softened, desized, or imprinted (Figure 29) with a special device described further in the patent. The areas treated should be simultaneously imprinted or dyes in order to make the writing more legible and to protect it. The purpose of this process is security against erasure or alteration of the value designations, etc of the checks, and alterations are not supposed to be possible without destroying the paper.

In US patent No 936399 the same inventor describes a further development of the preceding process in which the numerals are surrounded with perforations, etc, only in their immediate vicinity (Figure 30). Not all of the space between numerals is treated. There is a distinctive type of goffering or crimping for each letter or numeral. This is supposed to prevent raising the value of a check by transposition or substitution of individual numerals. Transposition can only be made by cutting out a numeral and affixing it somewhere else. However, this would make the latter area thicker and easy to detect. This sort of transposition can be more readily performed on a check written out according to US patent No 869823. One of the simplest methods of raising the value of a check consists in altering the first or last digit of the number designating its amount by cutting out a section of the check, replacing it with a different piece of paper, and imprinting the spurious character. To make this already very difficult operation still more difficult, the numerals are each given a different size and thickness.

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Another process using a similar device is claimed by E. E. Angell (Todd Protectograph Company, Rochester) in US patent No 1282166. In this case the spaces between the numerals are printed, perforated, and punched in dot form. Thus, superposition of other numerals or characters is supposed to be made impossible. The printed dots are supposed to be placed in the depressions between the elevations in the paper produced by the stamping or goffering. (Reference is also made to US patent No 849715 by the same inventor. It could not be dealt with here because the patent is out of print).

The theory of a check-writing process rather widely used in banks is explained in US patent No 1144742 (L. M. Todd and C. G. Tiefel; G. W. Todd and Company, Rochester). Two sets of characters are used; one for writing the amount of the check, the other to limit the written line (Figure 32). Those portions of the paper which carry the letters, numerals, or other symbols, are suitably damaged. For example, they may be cut through, goffered, and printed. The damage may be inflicted uniformly to the whole surface of the character or only at certain points, for example by means of fine lines. Stamping the ink into the broken areas of the paper serves to soak the paper thoroughly with dye and thus to make erasure or chemical eradication difficult. The line-limitation symbols are imprinted in a different color from that of the numerals, in order to make it more difficult to superpose the numerals of one line over those of another. A check-writer of this kind was patented by the same inventor in US patent No 1061508. Unfortunately such check-writers, which provide a high degree of protection against erasure, chemical corrosion, or other alterations, are exceedingly expensive and can only be acquired

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by the larger concerns. Their advantages may be attained more simply with suitable combinations of protective measures. Also, their protective value is always dubious if excellent guaranties of authenticity and safeguards against counterfeiting are not combined with their use. Furthermore, it is not impossible to repair perforations.

Professor doctor G. Obst in his Geld, Bank- und Boersenwesen [Money, Banking, and Exchanges], page 83, had the following to say about check-writing devices and similar protective methods. "The most secure among these preventive measures mainly benefit the banks themselves, in their own issues. The small or medium business man, for example, will hardly be able to acquire punching and stamping devices or a modern check-writing machine, which, when properly used, eliminates the possibility of all subsequent (but not prior) falsification of checks."

To this it may be added that nowadays it is technically possible to enjoy the protective advantages of a check-writing device without using the device itself.

Chapter VIII. Miscellaneous

Insofar as possible negotiable paper, such as checks, letters of credit, etc, obviously should be kept out of the hands of unauthorized persons. Therefore they should also be protected by appropriate security measures which are partly organizational and partly technical and which, when taken together can be very effective. Among the technical measures are the safe envelopes, etc, but their security value is usually quite dubious.

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We can only mention the numerous proposals for the manufacture of safety envelopes. Most of these proposals have not found any, or only limited, practical application. See German patents Nos 1297, 6042, 18130, 53689, 64689, 67060, 70474, 74871, 75945, 76030, 79030, 79279, 98512, and many others. They offer varying degrees of protection against the unauthorized opening of letters, or indicate it better than does the usual envelope. Furthermore, the illegal opening of an envelope is rather easily detected by a criminologist. Of course an envelope sealed in the usual way can also be robbed of its contents without opening it, for instance by the famous knitting-needle method. As moisture plays a role in most letter-openings, Harder and Bruening (Kriminalitaet beider Post [Crime in the Mails], page 136) recommend applying a rubber stamp impression in highly water-soluble dyes (see solvent indicators) to the envelope, or writing over the closed edges of the flap with an indelible pencil, or affixing seals of thin, colorless paper and outlining them with a sharp indelible pencil, or imprinting them with methyl green. Dark ultraviolet rays, too, may render good service in certain cases when there is doubt whether a letter has been opened or not.

To ensure against letters being opened, seals are of course usually employed. But the falsification -- removal and reapplication -- of seals is relatively easy (see especially K. Penn, "The Forging of Seals," in Tuerkel, Faelschungen [Forgeries], 1930, Graz, which also discusses safety methods. E. Goddefroy, Sur la fraude possible des plis charges et assures, portant des cachets a la cire [Frauds on Registered and Insured Letters Bearing Wax Seals], 1923, Brussels, recommends a safety locking device. See also Harder-Bruening, Kriminalitaet bei der Post, 1924, Berlin.

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For the sake of completeness, devices for photographing bank checks, documents, etc, according to German patent No 464344 (J. J. Kaplan, Boston, US), and German patent No 492546 (G. L. McCarthy, Eye, Westchester, US) are referred to. They are intended for use primarily by banks for registering checks. It frequently happens, in connection with a bank's check transactions, that the loss of paid checks, particularly of destroyed forged checks and other irregular items, perhaps as the result of the carelessness of messengers, etc, escape the bank's ineluctable systematic control. Photographing both sides of every canceled and paid check offers infallible proof that payment has been made, and protects the bank against bogus claims. The daily volume of checks previously made it impossible to photograph them, as earlier processes and apparatus were inadequate to handle the volume. Thus the banks had no sufficient proof to determine whether lost checks had already been paid or not.

These inventions claim to provide a means of satisfying this requirement.

German patent No 293745 and Supplementary patent No 302999 (doctor Carl G. Schwalbe, Eberswalde) deal with the destruction of negotiable documents. The object is to avoid undesirable but necessary manual labor on certain negotiable documents which may escape destruction when documents of this type are being burned or ground up in pulp machines. To accomplish this, the familiar process of carbonizing vegetable matter in woolen cloth is applied to the negotiable paper. The process transforms the paper into a completely triturated mass. In other words, the negotiable paper is treated with acids in gas or liquid form, especially hydrochloric acid,

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at high temperatures, for instance 120° C. If properly executed, for example in a revolving drum, no large fragments will remain. The small pieces which may still turn up are so soft that it would be impossible to put them together again for fraudulent purposes. According to the supplementary patent, chlorine gas may also be used. This is done in a carbonic acid atmosphere in order to eliminate fire hazards caused by the oxidation of the printing inks on the paper.

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DRP	413216	expired
DRP	416302	expired
DRP	416303	expired
DRP	422294	valid
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Drautz, A. B.

Eder, J. M.

Ehrlich, J.

Erfurt, J.

Erkens, J. W., ~~Maschinenfabrik~~ [Erkens, J. W. Machine Plant]

Europa Schreibmaschinengesellschaft [Europe Typewriter Company]

Farbenindustrie J. G. [IG Farben]

Fournier, Georges

Fues, E., doctor

Gailer, L.

Genouse, J.

Gernaert, J.

Gethe, H.

Giesecke und Devrient

Goddefroy, E.

Goethel, F.

Goppelsroeder

Hadert, H.

Halthof, W.

Harder-Bruening

Hartmann Gebr. Druckfarbenfabriken [Hartmann Bros. Printing Ink Factories]

Haussmann, E., doctor

Hilbert, E.

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Himmel, S. S.

Hoe and Company

Horstmann-Steinberg Dye Factory

Jackson, F. E.

Kalle and Company

Kaplan J. J.

Kleinewefers, W.

Knecht, E.

Koecher, H., doctor

Koegel, professor

Krueger, O.

La Monte George and Son

Lebateux, L.

Liesegang, F. R.

Lloyd, E. E., Paper Company

Locard, E.

Luettich, Max

McCarthy, G. L.

Macdonaugh

Mache, A.

Mellet, R., and Bischoff, A.

Menzies R. C., and Aitken, J. E.

Mercedes Bureaumaschinenfabriken [Mercedes Office Machine Factories]

Meyer, A. E.

Meyer, J. B.

Mitchel, C. A.

Mueller

Musil, E.

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Smith, B. W. Todd Protectograph Company

Snyder, T. J.

Snyder Document Protection Company

Spater

Steuer, P., doctor

Stirm, doctor

Thomassen, H.

Todd, L. M. and Tiefel, C. G. (G. W. Todd and Company)

Tuerkel

Veifa-Werke, Vereinigte Elektrotechnische Institute Frankfurt-Aschaffenburg [VEIFA Factories -- United Electrotechnical Institutes Frankfort Aschaffenburg]

Vereinigung der Berliner Banken und Bankiers [Association of Berlin Banks and Bankers]

Vogel, H. W.

Von Heinrich, F. (Nationalbank von Ungarn) [Hungarian National Bank]

Wadewitz, Martin, doctor

Walther

Walther, Bruno

Wandrowsky

Waterlow and Sons, Ltd. and Goodmann, E.

Werner und Schumann

Whitehead Morris and Company and Farmer, E. H.

Whitehead, Morris and Company and Morris, P.

Whitehead, Morris and Company, Morris, P. and Bryant, J. O.

Whitehead, Morris and Company and Pugh, J. P.

Wood, F. W. (Inkset Safety Paper Company)

Woodhull (American Bank Note Company)

Zeyen, L.

Zulassungsstelle an der Boerse zu Berlin [Admission Office of the Berlin Stock Exchange]

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Soap solution

Spirit of soap

Suds

Selective filter

Sensi colors

Safety envelopes

Safety printing

Safety printing, uncolored

Safety printing, technique

Safety printing, process

Safety papers

Safety papers, fluorescent

Safety papers, granite

Safety papers with thread inlays

Safety papers, white

Safety reagents

Safety typewriter

Safety seal locking method

Safety technique

Safety writing ink

Safety background impression

Safety negotiables

Protection against corrosion

Protection of negotiables against photocopying

Printed safety pattern

Safety methods, chemical

Safety methods against photomechanical reproduction

Safety methods, graphic

Safety methods, graphic

Safety papers

Photographic safety advice, on Koegelian principle of maximal-multiple accident

Safety technique, perfect

Mesh

Seal

Sealing wax

Seals (stamps)

Silver

Silver paper

Silver nitrate

Silver mercury iodide

Silver stearate

Soda, caustic

Spar

Sprinkling of paper

Atomizers

Nozzles

Spraying

Spray gun

Government bonds

Stability to light and humidity

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Starch

Strength of a paper

Starch paste

Steel engraving

Punching

Stearin

Stearic acid

Lithography

Stamp

Stamp-pad ink

Stylus

Stylus form

Confusion screen

Reflecting materials

Rays, blue

Rays, colored

Rays, infrared

Rays, ultraviolet

Rays, invisible

Rays, violet

Ink, coating

Single Stroke etching

Single stroke forgery

Topical etching

Single stroke bleach indication

Single stroke bleaching, protection against

Single stroke bleaching

Strokes

Line-shaded areas

Linear method

Linear pattern

Line erasure

Line drawing

Knitting needles

Electric current

Sulfanilic acid

Sulfites

Sulfite writing paper

Sulfite cellulose paper

Sulfocyanine GR

Synthesis

Talc

Tannin

Tapioca starch

Tartrazine

Coal tar dyestuffs

Oil of turpentine

Wills

Tetramethoxydiphenoquinone

Texture

Texture background impression

Thermochromism

Thermoplastic

Thiazines

Thiosulfates

Thiocyanate

Thioindigo dyestuffs

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Gravure

Gravure process

Ink

Printing ink

Conducting ink

Light fast ink

Inks containing ions of heavy metals

Sympathetic ink

Indelible ink

Ink, used in printing

Ink eradicators

Ink bleaches

Ink removers

Colored ink

Ink dyestuffs

Ink oxidizers

Ink writing

Ink writing, dried

Ink writing, fixation of

Indelible pencil

Tintentod ["Ink Death" eradicator]

Ink distributing device

Titanous chloride

Titanic acid

Tolidine hydrochloride

Toluidine o- and m

Tone

Tonal gradation

Tonal values

Shaded drawing

Total forgery

Tourist drafts

Tragacanth

Transcrit process

Transparent yellow

Transposition

Traveler's checks

Triacetine

Triphenyl guanidine

Triphenyl methane

Turnbull blue

India ink

Tuschex

Tuto

Type, forms of

Covering

Masking

Masking indicators

Overprinting, not erasure-proof

Overprinting with varnish

Coloring over

Pasting over

Lacquering over

Writing over

Painting over

Ultramarine

Ultramarine blue

Ultramarine green

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Ultramarine violet

Ultraviolet

Ultraviolet fluorescence

Ultraviolet luminescence

Reprinting

Background printing

Background

Underprinting

Background drawing

Signatures

Investigation methods, criminological

Uranine colors

Uranium salts

Documents

Ursoles

Vanadium salts

Vaseline

Falsification

Discoloration

Discoloration of paper

Discoloration, irreversible

Thickener

Thickener or binder

Couching

Contracts

Confusion pattern

Four-color photography

Viscosing

Violuric acid

Roller

Wax

Wax emulsion

Heat indicators

Laundry marking ink

Lacquer for roller

Warning signal

Warning signal, invisible

Warning signal, hidden

Warning symbols

Water

Watercolors

Watercolors with binders or thickeners

Watercolors without thickeners

Watercolors without fillers

Watercolor printing

Hydrogen ion concentration

Hydrogen peroxide

Watermark

Watermark, genuine

Watermark, imitated

Watermark, false

Watermark printing

Watermark printing ink

Watermark inks

Watermark forms

Watermark damages

Watermark ink

Exchange

Striking away

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Tartaric acid

Languages of the world

Printing of negotiables

Valuable documents

Valuable documents, protective inks for

Value indications, secret

Securities

Reproduction, photographic

Wool

Numerals

Zapon varnish

Sign

Drawing

Drawing, in register

Cellulose

Cellulose fibers

Destruction of valuable documents

Cigarette revenue stamps

Zincography, line

Zinc plate lithography

Zinc oxide

Zinc sulfate

Zinc sulfide

Zinc white

Tinn

Tin plate

Stannous chloride

Tin powder

Tax certificates

Citric acid

Sugar

Couching together

Pasting together paper strips

Addition

Forgery by addition

Possibilities of addition forgery

Cyananthrol

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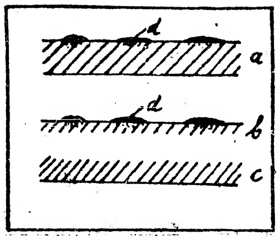

Figure 1. Splitting. a shows a section of the paper with handwriting; d represents the ink; b and c show the result -- b is the part split off and c the part of the paper remaining.

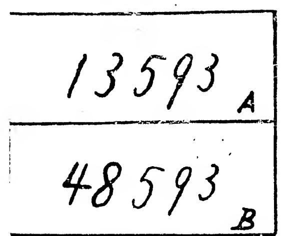

Figure 2. Forgery by addition. A shows a numeral before forgery; B after forgery.

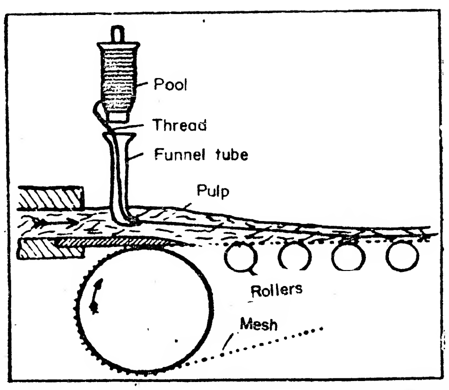

Figure 3. Diagram showing motion of pulp and injection of thread in paper-making machine producing paper with inlaid threads.

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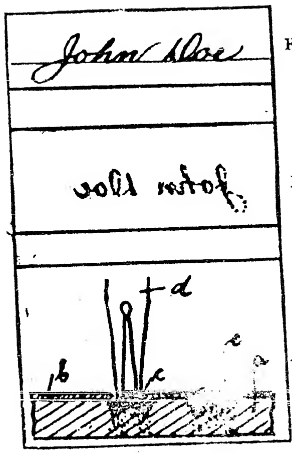

Figure 4. Signature on safety paper manufactured according to German patent No 546627.

Figure 5. The signature shown in Figure 4 is visible on the reverse of the same paper.

Figure 6. Layer b of the safety paper manufactured according to German patent No 546627 is punctured at c when inscribed by pen d , and the ink soaks all the way through to the reverse side of paper a . Drawing represents cross section.

Figure 7

Figure 8

Figure 9

Figure 10

Figure 11

Figure 12

Figure 13

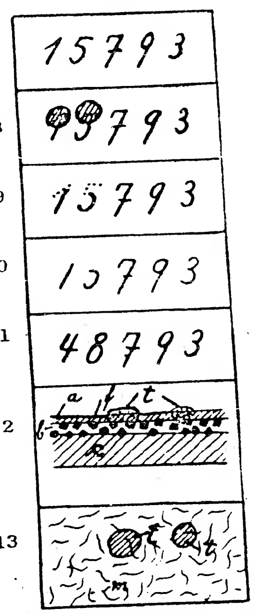

Figure 7. Written numerals before application of corrosive.

Figure 8. Complete drops of the corrosive are applied to the round, hatched areas. This procedure makes it easier to establish that a corrosive was applied.

Figure 9. Stroke bleaching. The corrosive is applied only to the portions of

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the numerals indicated by dots. This procedure makes it more difficult to establish subsequently that a corrosive was applied.

Figure 10. Appearance of the numerals in Figure 7 after eradication with a corrosive.

Figure 11. Appearance of the numerals in Figure 7 after forgery.

Figure 12. Cross section of safety paper with solvent indicator. The paper consists of a very thin top layer a made of granite paper or a paper which contains a forgery indicator. This aayer is bonded to another layer of paper c by a bonding agent b , which contains a great variety of dye particles f in suspended rather than dissolved form. When a drop of a liquid t is applied, it soaks through a and dissolves the dye particles f .

Figure 13. Vertical view of paper with solvent indicator shown in Figure 12. A colored spot (hatched) appears at the points where drops t were applied; m represents the colored fibers in the granite paper.

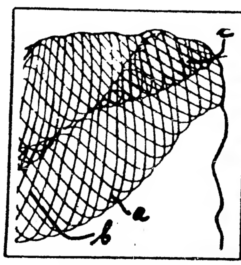

Figure 14

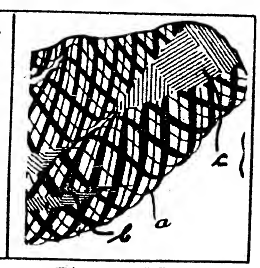

Figure 15

Figure 14. Enlarged detail of a guilloche.

Figure 15. Guilloche of Figure 14 showing the sections which have been thickened or hatched.

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Figure 16

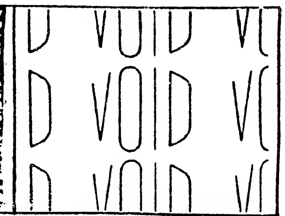

Figure 17

Figure 16. A warning signal, the word ' void , in extremely thin strokes, is masked by a design printed in sensitive inks.

Figure 17. When a safety paper like that shown in Figure 16 is treated with ink eradicator the warning signal appears plainly.

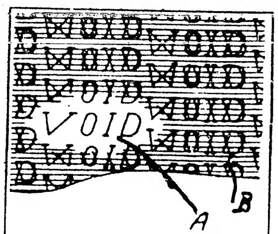

Figure 18

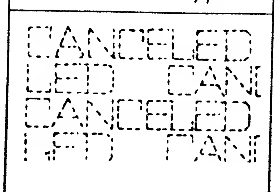

Figure 19

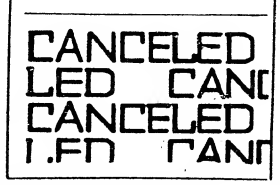

Figure 20

Figure 18. Imprinted disguised warning signal. When treated with corrosives, the masking disappears and the warning signal A appears prominently.

Figure 19. The letters in broken lines are printed in invisible forgery indicators.

Figure 20. When treated with ink eradicators the invisible warning signals in Figure 19 become visible.

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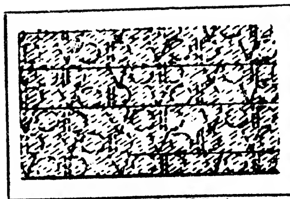

Figure 21

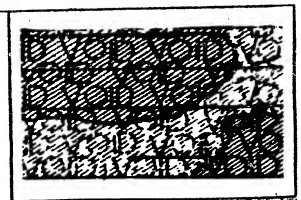

Figure 22

Figure 21. The paper is completely impregnated with forgery indicators (thin, broken lines), and overprinted while wet with invisible warning signals (broken letters).

Figure 22. When the paper in Figure 21 is treated with ink bleaches, the area in question is completely discolored and the warning signals become visible.

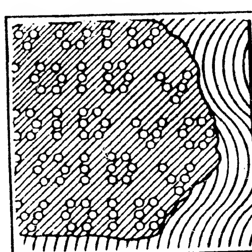

Figure 23

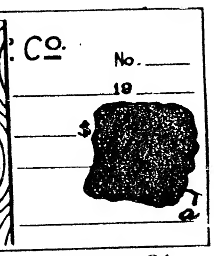

Figure 24

Figure 23. Negative print of the warning symbol. This consists of uninterrupted elements (small circles) within which there is no color. The invisible indicator color is represented by straight strokes. The wavy lines represent a graphic safety technique against mechanical erasure.

Figure 24. Section of a blank check of the type shown in Figure 23. It was treated with an ink eradicator at a , as a result of which the warning symbol has become visible.

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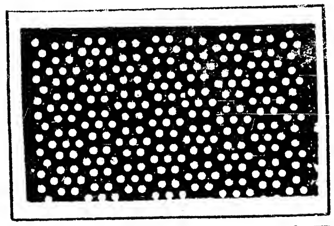

Figure 25

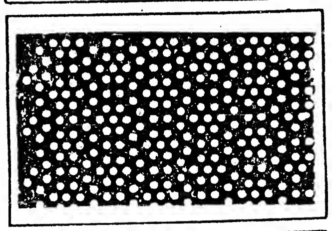

Figure 26

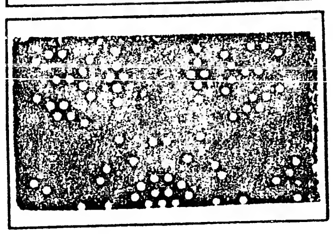

Figure 27

Figure 25. One pattern component used to produce the confusion pattern in Figure 27. The hatched portions are printed with ink; the white circles are left unprinted.

Figure 26. Second component of the confusion pattern in Figure 27.

Figure 27. Confusion pattern produced by superimposition, out of register, of the components shown in Figures 25 and 26.

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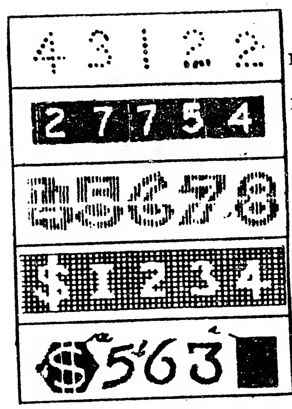

Figure 28

Figure 29

Figure 30

Figure 31

Figure 32

Figure 28. Enlarged view of numerals written with a safety typewriter. The dots represent holes in the paper.

Figure 29. Numerals written with a check-writer. The shaded areas are punched through, goffered, desized, or imprinted. US patent 869823.

Figure 30. Numerals written with check-writer. US patent 936399.

Figure 31. Numerals written with check writer. The squares represent goffered elevations; the lines, depressions which are perforated in dots. US patent 1282166.

Figure 32. Numerals written with check-writer. The shadings represent goffered and imprinted areas. a is printed in a different color from b . US patent 1144742.

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